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The Empirical Study of the Equity Premium Puzzle in China's Stock Market

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3. Description of Methodology
4. Empirical Study of the Equity Premium Puzzle in China's Stock Market
5. Conclusion

Bibliography
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Annexes

References:

BURTON, T. Edwin and Sunit, N. SHAH. *Behavioral finance: Understanding the social, cognitive, and economic debates*. Hoboken: Wiley, 2013. ISBN 978-1-118-30019-0.
MEHRA, Rajnish. *Handbook of the Equity Risk Premium*. Amsterdam: Elsevier Science, 2007. ISBN 978-0444508997.
WALTER, E. Carl and Fraser, J. T. HOWIE. *Privatizing China: The Stock Markets and Their Role in Corporate Reform*. New Jersey: John Wiley & Sons, 2003. ISBN 978-0470821206.

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Content

1 Introduction

Mehra and Prescott first proposed the equity premium puzzle (EPP) in their paper "The Equity Premium: A Puzzle" in 1985. The EPP refers to the inability of standard intertemporal economic models to rationalize the statistics that have characterized U.S. financial markets over the past century (Mehra, 2003). In other word, the actual premium is much larger than the premium estimated by the standard capital asset pricing model. This discrepancy between actual premium and theoretical premium gives rises to the EPP. Using empirical data of US financial market, Mehra and Prescott (1985) found that the US stock market yield from 1889 to 1978 was about 6.98%, while the US risk-free rate, the average annual income of treasury bills was about 0.8%. The excess return of the stock is 6.18%, while the theoretical one is only 1.4%.

The study of the magnitude of the equity premium (EP) and the equity premium puzzle is crucial to the real economy as EP plays an important role in the portfolio decision analysis and capital cost estimation, influencing investment decisions of individuals, corporations and financial institutions. The EPP reveals the fact that the price of systematic risk is much larger than what would be expected on the basis of rational optimization in efficient capital market. And Campell and Cochrane (1995) suggested that it was likely that the welfare cost of economic fluctuations was also much larger than the value predicted by standard model. Thus, it is meaningful to study the EPP in China's stock market as it has implications not only for investors but also for policy makers.

The objective of this thesis is to study whether the EPP exists in China's stock market. China's capital market started late in 1990s. Researches on the EPP are few and still at the initial stage. A unified conclusion on EPP in China's stock market hasn't been formed yet. Some empirical results found by Xiao and Wang (2004) and Lin (2007) indicate that there is no EPP in China, but other empirical results found by Du and Wang (2011) indicate that there is an EPP in China.

Methodologies employed by this thesis are the estimation method of coefficient of relative risk aversion (CRRA) and EP used by Mehra and Prescott (1985) and Hansen-Jagannathan minimum variance bound. The study period is from December 1990 to March 2019. The input data for the estimation are riskless rate of return, rate of return on stock, inflation rate and per capita consumption data. Both the monthly data and annual data of the yield of Shanghai Composite Index, Shenzhen Component Index and Shanghai and Shenzhen 300 Index are used as the risky rate of return in Shanghai stock market and Shenzhen stock market. The one-year deposit rate is employed as the riskless rate of return. The total retail sales of consumer goods are used as consumption data. CPI is used as inflation data.

In the second chapter, a brief overview about the development of China's stock market is presented. The consumption capital asset pricing model (CCAPM) is briefly introduced since it is the basis for the estimation of CRRA and EP. Both foreign and domestic literature reviews about EPP are described. Possible explanations such as risk-based, non-risk based explanation and behavioral finance explanation for this phenomenon are given.

The third chapter is about the description of methodology including the estimation of the CRRA and Hansen-Jagannathan bounds. The actual EP and CRRA are compared with the theoretical EP and CRRA respectively. If the actual EP or CRRA is higher than the theoretical one, there is the evidence for EPP. Also, if the standard deviation of actual stochastic discount factor (SDF) is lower than the theoretical minimum variance of SDF, the EPP exists.

In the fourth chapter, it is the empirical study about the presence of the EPP in China's stock market, utilizing the methodology mentioned in chapter three. Firstly, the data used for calculation are described and adjusted. Later the EP, CRRA and standard deviation of stochastic discount factor are calculated and compared with the theoretical ones obtained by standard model.

The last part is the conclusion. It provides the overall results of empirical study and implications of EPP for investors and policy makers.

2 Theory of Equity Premium Puzzle

In this part, a brief view about the development of China's stock market is presented. Detailed information about the Shanghai stock market and Shenzhen stock market such as the total capitalization, average P/E ratio, stock turnovers and accounts opened are provided. It also briefly introduces the consumption capital asset pricing model (CCAPM) which is the basis for the estimation of CRRA and EP. Both foreign and domestic literature reviews about EPP is described. Possible explanations such as risk-based, non-risk based explanation and behavioral finance explanation for EPP are provided.

2.1 China's Stock Market

The establishment of Shanghai Stock Exchange (SHSE) and Shenzhen Stock Exchange (SZSE) signifies the beginning of China's stock market. Shanghai Stock Exchange opened on 19th December, 1990, and Shenzhen Stock Exchange opened on 16th April, 1991.

As an emerging stock market, China's stock market has achieved rapid growth and remarkable achievements in just over two decade. The trading and settlement networks of the SHSE and SZSE cover all parts of the country. A unified national stock regulatory system has been established and has been gradually improved. The stock market plays a prominent role in promoting the reform of state-owned enterprises and promoting China's economic restructuring and technological progress. Also, China's stock market has gradually integrated into the international financial market and has become an important part of it.

On the one hand, the stock market is an important platform for corporate finance. Its operating efficiency directly determines the financing ability of listed companies, which affects the operation and development of enterprises; on the other hand, China's stock market has been a place where many investors have participated extensively. Both institutional investors and individual investors frequently invest in the market. Therefore, the stock market is highly active. The development of the stock market is directly related to the interests of many investors. It affects the stability of the economy and society.

With the continuous deepening of China's reform and opening up, economic development has moved to a middle level, and the improvement of people's living standards makes the stock market a great progress.

In the Table 2.1, it shows the information about China’s stock markets. All data are downloaded from the website of China Security Regulation Commission and Eastmoney.

Table 2.1 Details about China’s stock market

Time	Publicly Listed Company	Total Capitalization (Billion)	Total Circulation Value (Billion)	Average P/E Ratio		Stock Turnover (Billion)	Accounts Opened (Million)
				SHSE	SZSE		
1998	851	1,950.57	574.56	34.4	30.59	2,354.42	42.6
1999	949	2,647.11	821.4	38.1	36.3	3,131.96	48.11
2000	1088	4,809.09	1,608.75	59.14	56.04	6,082.67	61.23
2001	1160	4,352.22	1,446.32	37.59	39.79	3,830.52	68.99
2002	1244	3,832.91	1,248.46	34.5	36.97	2,799.05	72.02
2003	1287	4,545.77	1,317.85	36.54	20.92	3,211.53	73.44
2004	1377	3,705.56	1,168.86	24.2	24.63	4,233.37	72.11
2005	1381	3,243.03	1,063.05	16.38	16.96	3,166.48	73.36
2006	1434	8,940.39	2,500.36	33.38	33.61	9,046.89	78.54
2007	1550	32,714.09	9,306.44	59.24	72.11	46,055.62	92.81
2008	1625	12,136.64	4,521.39	14.86	17.13	26,711.26	104.5
2009	1718	24,393.91	15,125.87	28.73	46.01	53,598.67	120.38
2010	2063	26,542.26	19,311.04	21.61	44.69	54,563.35	133.91
2011	2342	21,475.81	16,492.13	13.4	23.11	42,164.67	140.5
2012	2494	23,035.76	18,165.82	12.3	22.01	31,466.74	140.46
2013	2489	23,907.72	19,957.95	10.99	27.76	46,807.14	132.47
2014	2613	37,254.70	31,562.43	15.99	34.05	74,391.30	142.15
2015	2827	53,130.42	41,792.54	17.63	53.62	255,053.84	139.11
2016	3052	50,824.51	39,326.63	15.94	41.21	127,384.40	135.71
2017	3552	56,621.12	45,051.11	18.16	36.21	102,462.51	133.98
2018	3584	43,329.60	35,245.55	12.49	20.17	96,539.45	146.5

Source: China Security Regulation Commission, Eastmoney

By the end of 2018, the number of accounts opened was 146.5 million, and 3,584 companies were listed in SHSE and SZSE with a total market capitalization of 43,329.6 billion yuan. From the reform of non-tradable shares in 2005 to the Shanghai-Hong Kong Stock Connect in 2014, China's stock market has been continuously developed rapidly in recent years. This also encourages the active participation of Chinese investors. However, the China's stock market faced downward pressure in 2018. By 29th June, 2018, the Shanghai Composite Index fell dramatically under 3000 points, and by 28th December, 2018, it reached 2493.9 points, setting a new low since 2016. But since the beginning of 2019, the Shanghai Composite Index has experienced a 27% increase reaching 3170.36 at the end of March 2019.

After looking at China's stock market, a brief introduction about the consumption capital asset pricing model (CCAPM) is needed to better understand the EPP because the method for testing the puzzle is derived from CCAPM.

2.2 Consumption Capital Asset Pricing Model

The equity premium puzzle was firstly described by Mehra and Prescott (1985). The equity premium puzzle is based on the consumption capital asset pricing model (CCAPM). To have a deeper understanding of this puzzle, a more comprehensive understanding of CCAPM is necessary. Markowitz's (1952) proposed the portfolio theory, and Sharp (1963) proposed market portfolio theory on the basis of Markowitz's theory. The theory is that the expected return of any asset is linearly related to the expected return of the market portfolio. Lintner (1965) and Mossin (1966) developed a capital asset pricing model (CAPM) after improving the market portfolio theory, that is, the return of any asset or portfolio is linearly positively correlated with its systemic risk. CAPM is an asset pricing model based on static analysis. It does not consider dynamic investment strategy choices. Therefore, Merton (1973) proposed the intertemporal capital asset pricing model (ICAPM) based on multi-period optimization. The model is no longer the one-factor pricing model; instead, the return of an asset is determined by multiple factors. Systemic risk is only one of them, and the rest are state factors that affect the return. Based on ICAPM, Breeden (1979) incorporated consumption data into asset pricing and constructed a capital asset pricing model based on the expected utility function determined by consumption (CCAPM), linking consumption to asset pricing.

2.3 Equity Premium Puzzle

Equity premium refers to the return earned by a broad market index in excess of that earned by a relatively risk-free security. The equity premium puzzle was firstly described by Mehra and Prescott in their essay “The Equity Premium: A Puzzle” in Journal of Monetary Economics in 1985. It remains a mystery to financial academics to this day. The equity premium puzzle refers to the inability of standard intertemporal economic models to rationalize the statistics that have characterized U.S. financial markets over the past century (Mehra, 2003). In other word, the actual premium is much larger than the premium estimated by the standard capital asset pricing model. This discrepancy between actual premium and theoretical premium gives rise to the equity premium puzzle.

Mehra and Prescott looked at a 90-year period of stock returns, from 1889 to 1978, and estimated the average stock return, corrected for inflation, to be 6.98%. They calculated an average real return on relatively riskless securities over the same period which was 0.8%. The equity premium in their data is 6.18%, which is much higher than the equity premium 1.4% calculated by CCAPM model. The puzzle arises because this unexpectedly large percentage implies an unreasonably high level of risk aversion among investors and it can’t reflect a proper level of compensation that would occur as a result of investor risk aversion.

2.3.1 Foreign Literature Review

Mehra and Prescott (1985) introduced Lucas’s utility function to calculate the equity premium to address the puzzle. In their following research, they further explored how scholars worldwide contributed to solving this puzzle even though the answer has not been found yet. They reported that the puzzle remained a puzzle and there were the same situations for United Kingdom, Germany, Japan and France. Later on, Mehra (2006) calculated the equity premium which was 11.3% in India and came to the conclusion that the equity premium puzzle also existed in India.

Epstein and Zin (1989, 1991) came up with the general expected utility function (GEU). It can be used to solve the problem of high intertemporal substitution elasticity and a high relative risk aversion factor existing at the same time. But they found this explanation for the equity premium puzzle was limited. Pastor and Stambaugh (2001) used the Bayesian method to estimate the risk premium. They found the relationship between risk premium, volatility and the stock price, and they concluded the range of risk premium was not likely to be too large.

Damodaran (2008) started with different methods of calculating the equity premium. He used historical data and statistical survey to estimate the premium, and also used current stock prices or risk premiums in non-stock markets to estimate the future equity premium. He compared the advantages and disadvantages of different methods. He concluded that the standard method was binding to some extent and the availability of data was limited, especially in countries with newly emerging markets. He explained why different methods get different returns and how to choose the "correct" method for analysis. He calculated the equity premium during financial crisis from September 2, 2008 to October 16, 2008, and concluded that the equity premium depended on the forecast period.

Edelstein and Magin (2012) estimated the equity risk premium of US real estate investment trusts (REITS). A random tax is introduced to the shareholders' shares of the REITS fund. Their analysis shows that the expected risk premium after tax for REITS produces a reasonable CRRA under 10. Using a series of credible random tax burdens, the CRRA of REITS shareholders is likely to fall between 4.3 and 6.3.

Favilukis (2013) observed the UK's economy over the past 30 years, and studied several phenomena such as uneven wealth distribution, increasing participation in the stock market, uneven consumption, small increases in household debt, and falling interest rates and equity premiums. He used an iterative model in an incomplete market, and tried to explain these phenomena above by the increase of wage inequality, the reduction of participation costs and the reduction of borrowing restrictions. After explaining those phenomena, it was found that the stock market played an important role in increasing the imbalance of wealth. He concluded that those phenomena must be considered together, otherwise, research would lead to counterfactual predictions.

Arouri (2013) studied the relationship between equity premium and regional integration, and assessed the impact of stock market segmentation on risk premium at the regional level. He estimated the degree of segmentation over time from one region to another. In addition, there are some major similarities and differences between developed and emerging stock market: (1) the total risk premium is significantly higher in emerging market; (2) the premium is more volatile in emerging market; (3) both markets are influenced by regional residual risk factors. He concluded that the emerging market became less fragmented due to liberalization reforms, and the magnitude of the equity premium gradually increased due to global risks.

Guesmi and Teulon (2013) tried to estimate the degree of integration of the Japanese stock market over time. They considered the dynamic process of market integration, regional market risk premium, inflation premium and local market risk premium, and concluded that (1) In Japan, the risk premium was extremely sensitive to major international economic and political events such as 1997, 1998 and 2001 financial crises in Asia, Latin America and other countries; (2) the level of market openness and the development of the stock market signified the integration of Japan's stock market.

Fernandez et. al. (2009) suggested that many market participants such as stock investors, investment banks, analysts, companies, etc did not use the standard theories such as the consumption asset capital pricing model to determine the premium they require. Instead, those market participants use historical data and advice from textbooks and finance professors. It results in a high equity premium. In order to solve the equity premium puzzle, they later conducted a statistical questionnaire survey of the risk-free interest rate and equity premium in 51 countries in 2013.

Tamura and Matsubayashi's (2014) utility function proposed a new approach to solving the equity premium puzzle. This approach is consistent with solution of the equity premium puzzle proposed by Mehra and Prescott (1985). Their study indicates that a consistent solution is possible for the equity premium puzzle even when there is a standard utility function with constant coefficient of relative risk aversion (CRRA). They standardized the Euler equation for consumption by adding the precautionary savings effect. The utility function they used under income uncertainty can be expressed as

$$U'(C_t) = C_t^{-\gamma}[1 + 0.5(\gamma + \gamma^2)CV_t^2], \tag{2.1}$$

where C_t represents the individual's real consumption at period *t*, CV_t represents the income, CV_t^2 represents the square value of CV for consumption at period *t*: $CV_t^2 = (\frac{h_t}{C_t})^2$, where h_t represents the standard deviation of consumption under uncertain income at time *t*, and γ is a constant degree of relative risk aversion.

Baetje and Menkhoff (2015) demonstrated that the technical indicators delivered stable economic value in predicting the US equity premium from 1966 to 2014. By contrast, economic indicators played a good role in prediction only until the 1970s, but since then they lost predictive power, even when the last crisis was considered. The predicative power of technical indicators is translated into a standard investment strategy, providing an annualized average Sharp ratio of 0.55 for investors who entered the market at any time point.

2.3.2 Domestic Literature Review

In China, domestic scholars' researches on equity premium start late, and stay at an initial stage. Some scholars analyze the premium level from the financial performance of listed companies. For example, Chen el. al (2002) focused on the risk premium and bubble metrics of China's stock market. They empirically studied the risk premium of China's stock market with company size, stock price, market value ratios and stock extraordinary return. Their analysis is to measure the extraordinary return on stock from the internal market. They did not analyze from the perspective of capital asset pricing and external influences on the market. Zhu and Zheng (2003) analyzed the impact of period selection, transaction costs, and equity size on equity premium. Wang (2004) constructed a series of investment portfolios for seven years starting from 1995. He examined the portfolio performance, and concluded that there was a significant high equity premium in the China's stock market.

Chen (2007) used Fama and French (2004) three-factor and five-factor model to test whether the China's stock market can be explained by the model. She concluded that the model was applicable to the China's stock market. Wang and Zhu (2011) conducted a detailed empirical study on the cross-sectional differences of the risk premiums of A-shares in China's stock market through asset pricing theory and empirical research. They established an eight-factor model based on market risk premium, book-to-market ratio, profit-to-price ratio, cash flow stock price ratio, investment capital ratio, industrial value added rate of change, repo rate, and maturity spread.

Liao and Wang (2003) first followed Mehra and Prescott's method to measure the risk premium of China's stock market. However, the selected period is only 5 years. Zhang (2005) derived a behavioral asset pricing model considering the characteristics of China's stock market. But he found that the model couldn't explain the puzzle of China's stock market. Tao (2007) added the characteristics of the Markov chain absorption state to the consumption capital asset pricing model (CCAPM), and developed a new algorithm to solve the high equity premium puzzle. She only theoretically analyzed the puzzle and did not conduct an empirical analysis. Wang (2007) examined the income constraint hypothesis with urban household consumption expenditure data grouped by income. She examined whether the consumption pattern of high-income residents was more consistent with CCAPM. However, she failed to solve the equity premium puzzle in China by incorporating income constraints into CCAPM. Later, she investigated the influence of participation constraints on equity premium. Li (2008) introduced the structural consumption differences of Chinese residents into the asset pricing model. She concluded that the structural consumption difference had a significant impact on equity premium in China's stock market.

Wang and Ma (2010) employed the weighted average earnings per share as variable for dividend growth and consumption growth in CCAPM under the complete market framework. It was found that there was no such puzzle in China's stock market. Zhu, Xie, and Rong (2009) used GARCH, EGARCH and intertemporal capital asset pricing model (ICAPM) to study the time-varying problem of equity premium in China's stock market.

Deng (2012) revised the generalized expected utility model of Epstein and Zin (1991), and used the H-J variance bounds to test whether the equity premium puzzle existed in China's stock market. He also compared the CRRA model, the Epstein and Zin model and the revised model. Han (2013) adopted a recursive form of consumption capital asset pricing model. He used GMM method to empirically study the return rate of China's stock market. He concluded that the consumption capital asset pricing model based on recursive utility form had a more reasonable explanation for the equity premium puzzle. Shao, Li, and Luo (2013) believed that the China's stock market was affected by a large number of irrational noise traders who make decisions regarding buy and sell trades without the support of professional advice or advanced fundamental analysis. Their conclusion is that it is necessary for the company to eliminate the risk premium of noise trader in order to calculate the risk premium when making project decisions.

Zhu and Zheng (2013) explained the equity premium puzzle through the myopic loss aversion in the prospect theory in behavioral finance. Zhang (2015) only theoretically described the impact of consumption and other factors on equity premium in China's stock market, but did not conduct empirical research.

2.4 Explanation for Equity Premium Puzzle

Many attempts have been put on resolving the equity premium puzzle. Possible explanations about the equity premium puzzle can be mainly divided into three kinds, risk-based explanation such as generalized expected utility, habit formation and survivorship bias, non-risk based explanations such as transaction costs, borrowing constraints and tax regulation, and the newly developed behavioral finance explanation such as myopic loss aversion.

2.4.1 Risk-Based Explanation

The risk-based explanation includes generalized expected utility, habit formation and survivorship bias. They will be illustrated as follows.

a) Generalized Expected Utility

The generalized expected utility (GEU) which is developed by Epstein and Zin (1987) and Weil (1989) based on the work of Kreps and Porteus (1978) allows independent specification of the coefficient of relative risk aversion (CRRA) and the elasticity of intertemporal substitution (EIS). EIS measures the extent to which a rise in real interest rate affects the real growth in consumption. If the relation is positive then it measures the income effect. If it is negative then it measures the substitution effect. A large value for the EIS denotes a high propensity to substitute future consumption for today's consumption, and a low propensity to smooth consumption, and hence less dislike for a growth in consumption. The generalized utility function assumes the following form,

$$U(C_t, CE_{t+1}) = \left[(1-\beta)C_t^{1-p} + \beta CE_t U_{t+1}^{1-p}\right]^{\frac{1}{1-p}}, \tag{2.2}$$

and

$$CE_t(U_{t+1}) = [E_t U_{t+1}^{1-r}]^{\frac{1}{1-r}}, \tag{2.3}$$

where $\frac{1}{p}$ is the elasticity of intertemporal substitution; γ is the coefficient of relative risk aversion; β is the subjective time discount factor; E_t is the expectation operator; C_t is the per capita real consumption; U_t is the utility function; $CE_{t+1} = CE_t(U_{t+1})$ is the certainty equivalent of next period's utility.

There has

$$U_t = [(1-\beta)C_t^p + (\beta E_t U_{t+1}^{\gamma})^{\frac{p}{\gamma}}]^{\frac{1}{p}}. \tag{2.4}$$

It is obvious from this definition that the CRRA and the EIS are independent. Epstein and Zin (1987) used monthly data from 1959 to 1978, and created several measures of consumption, asset return and instrumental variables. They came to the following general conclusion. When they estimated with real data, CRRA was close to one and the EIS was less than one. In this way, the separating of the two determining coefficients in utility preferences does not help to solve the equity premium puzzle as stated by Mehra and Prescott (1985) because the CRRA remains too low.

Based on Epstein-Zin preference constructs, further researches are done by Weil (1989) and Bansal and Yaron (2000). They all put efforts on analyzing invertors' preference structures. Although standard Epstein-Zin preferences do not necessarily go very far in resolving the equity premium puzzle, it is informative to study the implication of these preferences for the properties of equity returns.

b) Habit Formation

Habit persistence, or "habit formation" in its most common representation, is a preference specification according to which the period utility function depends on a quasi-difference of consumption, a difference between customers' current and past consumption (Constantinides, 1990). Under the framework of habit formation, preferences of an individual are, in addition to current period consumption, dependent on past consumption.

The equity premium puzzle is that, under the assumption of power utility and no habit persistence, observed excess returns of stocks over riskless assets, such as Treasury bills, are too high to be consistent with actual consumption behavior unless households are assumed to be extremely risk averse. At the heart of the equity premium puzzle lies the low volatility of observed consumption growth. To see this, note that a risky asset commands a high rate of return if it provides poor insurance against consumption fluctuations by paying plenty in periods of high consumption growth and little in periods of low consumption growth (Mehra, 2008). If fluctuations in consumption growth are small, then high returns on risky assets can be supported only if one assumes that even minute consumption fluctuations are very painful to consumers. In other words, one must assume that consumers are extraordinarily risk averse.

Early studies of the ability of habit formation to resolve the equity premium puzzle include Sundaresan (1989), Abel (1990), and Constantinides (1990). They concluded habit-forming consumers disliked variations in habit-adjusted consumption, $C_t - \alpha S_{t-1}$, rather than variations in consumption itself, C_t, where C_t is consumption at period *t*, and S_{t-1}= $S(C_{t-1}, C_{t-2} \ldots)$ denotes the stock of habit in period *t*. A given percentage change in consumption produces a much larger percentage change in habit-adjusted consumption than in consumption itself. In this way, small fluctuations in consumption growth can generate large variations in habit-adjusted consumption growth. Therefore, it explains sizable excess returns on risky assets even for moderate values of the degree of risk aversion.

c) Survivorship Bias

Survivorship bias means that the data sample used leaves out some data that has not "survived" for some reasons. It is the tendency for failed companies to be excluded from performance studies because they no longer exist. It often causes the results of studies not to reflecting the reality because only companies which are successful enough to survive until the end of the period are included. For example, a mutual fund company's selection of funds today will include only those that are successful now. Many losing funds are closed and merged into other funds to hide poor performance. Excluding the non-survivors creates a sample that will bias the average performance, because the non-survivors are more likely to have poor performance than the survivors.

In 1999, Jorion and Goetzmann reported results of investment performance that looked at global data. They argued that a global portfolio was an appropriate portfolio for a rational investor instead of a home-biased domestic portfolio. They thought every other country had lower equity performance on average, and several countries' stock markets simply ceased functioning in some periods during twenties century. Using data from 1921 to 1996, they estimated an annual median return of 0.8% for many countries in their study in contrast to a high 4.3% real return for the US stock market during the same period.

Brown, Goetzmann and Ross (1995) also focused on the survivorship bias. They proposed a hypothesis that all data samples, especially the long horizon ones, were subject to survivorship bias. They stated that it might be fruitful to consider the possible implications of the most pervasive ex-post conditioning in empirical finance: the survival of the return history to be included in the sample (Brown, Goetzmann and Ross, 1995). In other words, only stock markets that are able to navigate through different financial crises without discontinuity in return data are included in long-term studies. The past history of other major markets like Russia, China, Germany and Japan are less desirable to investors because each of these markets has had one or more major interruptions that prevent their inclusion in long-term studies. Therefore the expected returns on financial assets will be biased as the stock with poor performance are not survived and stock with good performance and higher returns survived. The authors showed that the bias is an increasing function of the volatility of returns. However, they did not conduct any empirical study using non-survivorship bias data.

2.4.2 Non-risk Based Explanation

Non-risk based explanations consist of transaction costs, borrowing constraints, and tax regulations. Definition and research related will be presented.

a) Transaction Costs and Borrowing Constraints

In models with transaction costs and borrowing constraints, the effect is to force investors to hold bonds for precautionary demand to smooth consumption. There are some recent attempts to resolve the puzzle incorporating both borrowing constraints and consumer heterogeneity. Constantinides, Donaldson and Mehra (2002) considered that consumers were heterogeneous, and they constructed an overlapping-generations (OLG) exchange economy in which consumers lived for three periods. In the first period, a period of human capital acquisition, the consumer receives a relatively low income. In the second period, the consumer is employed and receives wage income subject to large uncertainty. In the third period, the consumer retires and consumes the assets accumulated in the second period.

Compared to those middle-aged consumers who have relatively stable work and salary, the young are characterized by low and unstable wages. They would like to smooth lifetime consumption by borrowing against future income and investing the borrowing in high return equity. However, they are kept out of this market because of borrowing constraints. They are prevented from doing so because human capital alone does not collateralize major loans in modern economies. In the presence of borrowing constraints, equity is thus exclusively priced due to additional costs for funding. This view of the life cycle provides insights for solving the equity premium puzzle.

b) Taxes and Regulation

McGrattan and Prescott (2003) pointed out US stock prices increased much faster than gross domestic product (GDP) in the postwar period. Corporate equity value relative to GDP nearly doubled between 1962 and 2000. They thought the reason for the large increase in equity value relative to GDP was that the average tax rate on dividends fell dramatically between 1962 and 2000. They also found that, given legal constraints that effectively prohibited the holding of stocks as reserves for pension plans, there was no equity premium puzzle in the postwar period.

In McGrattan and Prescott's paper (2003), their theory predicts a large increase in equity prices between 1962 and 2000 due to the large reduction in individual income tax rates, the increased opportunities to hold equity in nontaxed pension plans, and the increases in intangible and foreign capital. They predicted a doubling of the equity value relative to GDP and a doubling of the price-earnings ratio. They come to this finding that it is the tax reduction causes high equity premium and there is no equity premium puzzle in the postwar period.

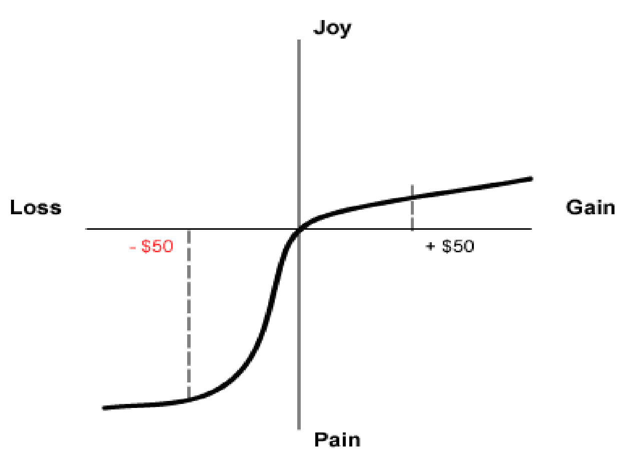
2.4.3 Behavioral Finance Explanation

The most well-known explanation about equity premium puzzle in behavior finance is the myopic loss aversion which is closely related to loss aversion and mental accounting.

a) Myopic Loss Aversion

Myopic loss aversion is a behavioral approach to decision processes focused on the combination of two specific concepts – loss aversion and mental accounting. Loss aversion refers to the tendency for individuals to be more sensitive to reduction in their level of well-being than to increases (Benartzi and Thaler, 1995). Kahneman and Tversky (1992) proposed the prospect theory in which utility was defined over gains and losses rather than levels of wealth, as opposed to expected utility theory. The utility function has a steeper loss function than the gain function. The ratio of these slopes at the origin is a measure of loss aversion. Empirical estimates of loss aversion are typically in the neighborhood of 2, that is to say, the disutility of giving something up is twice as great as the utility of acquiring it (Kahneman and Tversky, 1992). The Figure 2.1 shows the loss aversion is disproportional to gain satisfaction.

Figure 2.1 Loss aversion



Source: Investopedia

The mental accounting refers to the tendency people have to separate their money into different accounts based on miscellaneous subjective criteria. People establish mental accounts to compare the advantages and disadvantages between various options, which leads them to frequently calculate and evaluate financial results including transactions, investments, gambling, etc. Thus, long-term investment decision is actually based on an assessment of short-term gains (Edwin and Shan, 2013).

The two factors, loss aversion and a short evaluation period, contribute to an investor being unwilling to bear the risks associated with holding equities. This combination is myopic loss aversion. Put it another way, when decision-makers are loss-averse, they will be more unwilling to take risks if they evaluate their performance frequently.

The myopic loss aversion is a possible solution for the equity premium puzzle. When investors with myopic loss aversion make investment decisions, they tend to evaluate short-term gains and losses more frequently. However, short-term fluctuations are always more intense, and shorter evaluation intervals make them more sensitive to price fluctuations and thus consider the risks to be greater. The loss-averse investors feel that it is very painful to bear the short-term loss. Therefore, they will choose to sell their stocks and buy stocks with better gains. Investors are likely to increase their degree of loss aversion by more frequent evaluation of the gains and losses, which makes them more painful to face losses.

Due to myopic loss aversion, the utility function of investors has been changed, which in turn affects their psychological value, leading them to make behavioral decisions to sell their stocks and buy stocks with better gains more frequently. From the perspective of the market as a whole, the behavior of a large number of investors frequently trading stocks changes the supply and demand relationship of the stock market. It leads to large fluctuations in stock prices, increasing market volatility and market risks. For risk-averse investors, the market needs to provide them with more risk compensation in order to attract them to buy stocks instead of risk-free assets, which causes an increase in the equity premium level, thus forming a high equity premium phenomenon.

3 Description of Methodology

This chapter is about the description of methodology including the estimation of CRRA and EP based on CCAPM, Hansen-Jagannathan bounds and two statistic tests, Dickey-Fuller test and Durbin-Watson statistic. Those methods later will be utilized in the empirical study part.

3.1 Estimation of Coefficient of Relative Risk Aversion and Equity Premium

The estimation method of coefficient of relative risk aversion (CRRA) is derived based on the covariance of the stochastic discount factor (SDF) and the market portfolio return rate. Different estimates are constructed according to different utility functions. Therefore, it is necessary to comprehend stochastic discount factor and the utility function in order to have a comprehensive understanding about the coefficient of relative risk aversion.

3.1.1 Utility Function and Stochastic Discount Factor

Lucas and Breeden (1979) proposed a pure exchange model and assumed that there were no producers in the economy and that all economic parties were consumers. Each consumer has a certain number of commodities at the beginning of the period. All transactions are for consumption. The consumer utility is determined by the current utility and expected future utility. Under certain budget constraints, the economic parties follow the principle of maximizing utility to make decision. Consumption of the economic party determines the utility, and the pursuit of utility maximization prompts a person to make decisions, which affects the asset price. Assuming that the economic parties are homogeneous, and then each economic party can be seen as a representative investor.

A variation of Lucas (1978) pure exchange model was employed by Mehra and Prescott (1985). Since per capita consumption grows over time, an assumption is made that the growth rate of the consumption follows a Markov process, which is in contrast to the assumption in Lucas' model that the consumption level follows a Markov process. There are three basic conditions for the model proposed by Merha and Prescott (1985) to fit into the general equilibrium framework.

- Market participants have preferences which maximize the discounted expected value of future utilities, where utility is a power function.
- Markets are complete – market participants can insure themselves against possible unfavorable event.
- Markets are frictionless and rational – there are no trading costs, and taxes are assumed to be insignificant.

Consider a single representative permanently living household in a frictionless economy, which orders its preferences over random consumption paths by

$$E_0\left\{\sum_{t=0}^{\infty}\beta^t U(C_t)\right\}, 0<\beta<1 \tag{3.1}$$

where E_0 is the conditional expectation operator upon information available at time zero (the present time), and U is the increasing, continuously differentiable concave utility. β is the subjective time discount factor, which describes how impatient household are to consume. If β is small, people are impatient, which means people have strong performance to consumption now than to consumption in the future (Merha, 2008). Formula (3.2) shows the consumer's budget constraints,

$$W_{t+1}=(W_t-C_t)\sum_{i=0}^{n}w_{i,t}R_{i,t+1}, \tag{3.2}$$

and

$$\sum_{i=0}^{n}w_i=1, \tag{3.3}$$

where C_t is the consumption at t period, W_{t+1} shows the consumer's wealth at *t+1* period, and it is the gains in previous investment with the remaining money after completing consumption at *t* period. $w_{i,t}$ represents the weight of the *i* asset at *t* period among total asset, and $R_{i,t+1}$ shows the rate of return on asset *i* from *t* period to *t+1* period.

Under the budget constraints and goal of maximizing utility function, the Euler equation can be derived using the first order derivation of the Bellman equation, showing below,

$$\beta E_t\left[R_{i,t+1}U'(C_{t+1})\right] = U'(C_t), \tag{3.4}$$

$$E_t(M_{t+1}R_{i,t+1}) = 1, \tag{3.5}$$

and

$$M_{t+1} = \beta U'(C_{t+1})/U'(C_t), \tag{3.6}$$

where M_{t+1} is the stochastic discount factor which is determined by time discount factor and first derivative of utility function of consumption (Rubinstein, 1976).

3.1.2 Coefficient of Relative Risk Aversion and Equity Premium

In the utility function, the consumer's relative risk aversion coefficient (CRRA) is restricted to be constant, that is to say, the relative risk aversion coefficient of consumers at different consumption levels remains unchanged, and consumers with different wealth have the same relative risk aversion coefficient. Thus, every consumer in the economy can be regarded as a representative investor. The wealth level of the representative investor can be obtained through dividing the total wealth of the society by the total population, and the consumption level of the representative investor can be calculated through dividing the total consumption by the total population. As the utility function is restricted to be a constant CRRA, formula (3.7) is obtained. It is an increasing, concave and continuously differentiable function of a form

$$U(c,\alpha) = \frac{c^{1-\alpha}}{1-\alpha} \quad 0 < \alpha < \infty, \tag{3.7}$$

where the parameter α measures the curvature of the utility function and determines the risk aversion of the representative household. The bigger the α, the more risk adverse the individual is. In this utility function, the elasticity of intertemporal consumption is $1/\alpha$. When $\alpha = 1$, the utility function is defined to be logarithmic, and it is the limit of formula (3.7) as α approaches 1 (Weil, 1989).

The first advantage of preference function of choice is that it is scale invariant. That is to say, although the levels of aggregate variables, such as capital stock, have increased over time, the resulting equilibrium return process is stationary (Merha, 2008).

The second attractive feature is that it allows for aggregation which does not depend on starting allocation of endowments. One of the disadvantages is that it links the risk preferences with time preferences. In particular, the elasticity of intertemporal substitution is the inverse of the coefficient of relative risk aversion. With CRRA's preferences, agents who like to smooth consumption between good and bad time prefer balanced consumption over time; that is, they don't like growth. But there is no fundamental economic reason to explain why this is the case.

It can be assumed that the output of a productive unit at period *t* is y_t, which is also the dividend for this period. One equity share with price p_t is competitively traded and represents a stochastic process $\{y_t\}$.

Consider a decision a typical investor faces over time *t*. An investor can purchase an additional unit of equity which reduces his current utility in exchange for higher utility in next period when he sells the equity and fulfill consumption. The loss in utility linked with buying an additional unit of equity is equal to the discounted expected utility of additional consumption in the next period. In order to carry over an additional equity unit in next period, the consumption units must be sacrificed now, and the resulting loss of utility is $p_t U'(c_t)$. By selling the additional equity unit in future period, $p_{t+1} + y_{t+1}$ additional units of consumption can be consumed, and $\beta E_t\{(p_{t+1} + y_{t+1})U'(c_{t+1})\}$ is the expected value of the additional utility in next period. In equilibrium, the loss in current utility has to be equal to the expected gain in utility in the next period and can be formalized as follows,

$$p_t U'(c_t) = \beta E_t\{(p_{t+1} + y_{t+1})U'(c_{t+1})\}, \tag{3.8}$$

where the left side represents the loss in utility in period *t*, and the right is the discounted gain of utility in period *t+1* (Rubinstein, 1976).

Formula (3.8) can be used to price both risky assets and risk-less assets.

For equity, it has

$$1 = \beta E_t \left\{ \frac{U'(c_{t+1})}{U'(c_t)} R_{e,t+1} \right\}, \tag{3.9}$$

where

$$R_{e,t+1} = \frac{p_{t+1} + y_{t+1}}{p_t}, \tag{3.10}$$

and for riskless assets, it has

$$1 = \beta E_t \left\{ \frac{U'(c_{t+1})}{U'(c_t)} \right\} R_{f,t+1}, \tag{3.11}$$

where the gross rate of return on riskless asset is expressed as follows,

$$R_{f,t+1} = \frac{1}{q_t}, \tag{3.12}$$

and q_t is the price of the riskless asset.

We can rewrite the formula (3.9) as follows,

$$1 = \beta E_t\left(M_{t+1} R_{e,t+1}\right), \tag{3.13}$$

among which $M_{t+1} = U'(C_{t+1})/\,U'(C_t)$. M_{t+1} is a strictly positive stochastic discount factor. Such a definition would guarantee the economy to be arbitrage free and the law of one price rule to be held. A small algebra proves that the total expected return of the stock is like the following formula,

$$E_t\left(R_{e,t+1}\right) = R_{f,t+1} + Cov_t \left\{ \frac{-U'(c_{t+1}), R_{e,t+1}}{E_t\left(U'(c_{t+1})\right)} \right\}. \tag{3.14}$$

The equity premium can be easily calculated by $E_t(R_{e,t+1}) - R_{f,t+1}$. The expected rate of return on assets is equal to the risk-free rate plus the premium on risk exposure, which depends on the covariance of the return on assets with marginal utility of consumption. Assets with positive covariation of consumption, that is, assets which pay off when there are low marginal utility and high consumption require a high premium because these are assets that "destabilize" consumption.

In order to explain the equity premium puzzle, further assumptions are proposed by Mehra and Prescott (1985) as follows,

- the growth rate of consumption $x_{t+1} \equiv \frac{c_{t+1}}{c_t}$ is *i.i.d*;
- the growth rate of dividends $z_{t+1} \equiv \frac{y_{t+1}}{y_t}$ is *i.i.d*;
- (x_t, z_t) are jointly log-normally distributed.

From the above assumptions, there are two important consequences that the gross rate of return on equity $R_{e,t}$ is always *i.i.d*, and $(x_t, R_{e,t})$ follows a jointly log-normally distribution.

Substituting $U'(C_t) = C_t^{-\alpha}$ in the Formula (3.15)

$$p_t = \beta E_t\{(p_{t+1} + y_{t+1})\frac{U'(c_{t+1})}{U'(c_t)}\}, \tag{3.15}$$

and we can get,

$$p_t = \beta E_t[(p_{t+1} + y_{t+1})x_{t+1}^{-\alpha}]. \tag{3.16}$$

As the price of the equity p_t is homogeneous of degree one in y_t, we can represent it as

$$p_t = w y_t, \tag{3.17}$$

and we can get

$$R_{e,t+1} = \frac{(w+1)}{w}.\frac{y_{t+1}}{y_t} = \frac{w+1}{w}.z_{t+1}, \tag{3.18}$$

and it can be easily proved that

$$w = \frac{\beta E_t(z_{t+1}x_{t+1}^{-\alpha})}{1 - \beta E_t(z_{t+1}x_{t+1}^{-\alpha})}. \tag{3.19}$$

Finally we can get the expression for expected rate of return on risky assets as follows

$$E_t(R_{e,t+1}) = \frac{E_t(z_{t+1})}{\beta E_t(z_{t+1}x_{t+1}^{-\alpha})}, \tag{3.20}$$

and the gross return for riskless assets can be written as

$$R_{f,t+1} = \frac{1}{\beta E_t(x_{t+1}^{-\alpha})}. \tag{3.21}$$

Since we have assumed that the growth rate of consumption and dividends follows a log normally distribution, thus it can be obtained,

$$E_t\{R_{e,t+1}\} = \frac{e^{\mu_z + \frac{1}{2}\sigma_z^2}}{\beta e^{\mu_z - \alpha\mu_x + \frac{1}{2}(\sigma_z^2 + \alpha^2\sigma_x^2 - 2\alpha\sigma_{x,z})}}, \tag{3.22}$$

and

$$lnE_t\{R_{e,t+1}\} = -ln\beta + \alpha\mu_x - \frac{1}{2}\alpha^2\sigma_x^2 + \alpha\sigma_{x,z}, \tag{3.23}$$

where $\mu_x = E(lnx)$, $\sigma_x^2 = Var(lnx)$, $\sigma_{x,z} = cov(lnx, lnz)$, and lnx is the continuously compounded growth rate of consumption (Hansen and Singleton, 1982 cited in Merha and Prescott, 2008).

As for riskless assets, we can get

$$R_f = \frac{1}{\beta e^{-\alpha\mu_x + \frac{1}{2}\alpha^2\sigma_x^2}}, \tag{3.24}$$

and

$$lnR_f = -ln\beta + \alpha\mu_x - \frac{1}{2}\alpha^2\sigma_x^2, \tag{3.25}$$

therefore,

$$lnE(R_e) - lnR_f = \alpha\sigma_{x,z}. \tag{3.26}$$

From formula (3.18) it can also be expressed as

$$lnE\{R_e\} - lnR_f = \alpha\sigma_{x,\,R_e}, \tag{3.27}$$

where

$$\sigma_{x,R_e} = Cov(lnx, lnR_e). \tag{3.28}$$

The equity premium in this logarithmic model is the product of the relative risk aversion coefficient and the covariance of consumption growth rate and the equity return rate or dividend growth rate. If we impose the equilibrium condition that $x = z$, it will result in a restriction that equity return and consumption growth rate are perfectly correlated with each other, and we conclude

$$lnE(R_e) - lnR_f = \alpha\sigma_x^2 \tag{3.29}$$

and

$$\alpha = \frac{lnE(R_e) - lnE(R_f)}{\sigma_x^2}, \tag{3.30}$$

and

$$EP = exp\left(lnE(R_e)\right) - exp\left(lnE(R_f)\right). \tag{3.31}$$

From the expression above, we can see that the equity premium is the product of coefficient of relative risk aversion and variance of the continuously growth rate of consumption (Merha and Prescott, 2008).

The formulas above are derived from the consumption-based capital asset pricing model (CCAPM). The pricing idea of CCAPM originates from the equilibrium pricing idea of financial assets which is based on the framework of general economic equilibrium proposed by Arrow and Deberu in 1954. CCAPM studies more about the pricing of general commodities, and it assumes that consumers and producers are rational people. At the same time, under certain conditions, there is a generally equilibrium price that balances the supply and demand of goods. The CCAPM is actually the specific application of general equilibrium theory in the financial market. But we should also see the difference between the two. The CCAPM model is focused on the uncertainty. First, a model which maximizes utility function under budget constraints is constructed, representing individual's preference of financial asset. Also, intertemporal selection of consumption and investment under uncertain conditions is considered. Finally, the prices of financial assets under equilibrium conditions are determined.

Specifically, it is the choice of the representative individual between the current consumption and the future consumption. The opportunity cost of the current consumption is the profit from the current investment. Therefore, the optimal combination of current consumption and future consumption appears at the tangent point of the indifference curve and the budget constraint line. It is the optimal equilibrium, at which the marginal substitution rate of current consumption and future consumption is the ratio of their price. For example, if the current consumption's price is 1 unit and the future consumption's price is p unit. When it reaches the equilibrium, their marginal substitution rate is equal to $1/p$, which is the rate of return on assets. Thus, this standard model associates consumption to asset returns.

3.2 Hansen-Jagannathan Bound Test

Based on Euler's equation, the minimum variance bound of stochastic discount factor is proposed by Hansen and Jagannathan (1991). The theory of minimum variance bound can be used to test any kind of asset pricing model. They constructed the candidate stochastic discount factor (SDF) and came to the conclusion that the variance of the candidate stochastic discount factor was the theoretical minimum variance of the stochastic discount factor. If the actual variance of the stochastic discount factor is less than the theoretical variance, there is an equity premium puzzle. As mentioned above, the stochastic discount factor is related to the first derivative of the utility function of consumption. If the consumption data is smooth and the volatility is small, the volatility of the stochastic discount factor will not be high, and the actual variance of stochastic discount factor will be small as well. The advantage of the minimum variance bound is that the derivation process is not based on parameters, thus the parameter limits are less, and the derivation results are intuitive and easy to understand. The minimum variance bound is constructed as follows (Hansen and Jagannathan, 1991).

Firstly, assume that the random column n-vector R of the gross returns on the assets has mean $E(R) = \mu$ and covariance matrix Σ. A candidate stochastic discount factor is constructed as m such as $E(mR) = 1$. Hansen and Jagannathan (1991) showed that the SDF with minimum variance for its expectation $E(m)$ had

$$m^{\cdot} = E(m) + \{E'(mR) - E(m)E(R')\}\Sigma^{-1}(R - \mu). \tag{3.32}$$

Consider a regression of any m fulfilling $E(mR) = 1$, and $= m^{\cdot} + \varepsilon,$ where ε is the regression error satisfying $E(\varepsilon) = 0 = E(\varepsilon R)$. The minimum variance for SDF is the variance of $m^{\cdot}$ showed in formula (3.32),

$$\mathrm{Var(m)} \geq \{E'(mR) - E(m)E(R')\}\Sigma^{-1}\{E'(mR) - E(m)E(R)\}. \tag{3.33}$$

As the fundamental asset pricing equation places restriction on the mean and variance of $m,$ the formula (3.34) and (3.35) are obtained as follows

$$\frac{\sigma(m)}{E(m)} \geq \left|\frac{E(R) - R^f}{\sigma(R)}\right|, \tag{3.34}$$

or

$$\sigma(m) \geq E(m) \cdot \left|\frac{E(R) - R^f}{\sigma(R)}\right|, \tag{3.35}$$

where R^f is the riskless rate of return, $\sigma(R)$ is the standard deviation of R and $\sigma(m)$ is the standard deviation of SDF.

The right side of the formula (3.34) is absolute value of Sharpe ratio. The Sharpe ratio is limited by the volatility of the SDF. It is obvious that the theory behind the Hansen-Jagannathan bound is that the ratio of the standard deviation of a stochastic discount factor to its mean exceeds the Sharpe ratio attained by any portfolio.

Combine formula (3.13) and (3.22) with formula (3.34), the following expression can be derived,

$$E(m) = \beta\, exp(-\alpha\mu_x + 0.5\alpha^2\sigma_x^2), \tag{3.36}$$

and

$$Var(m) = \frac{1}{k}\left\{\sum_{t=1}^{k}\left(\beta(x_t)^{-\alpha} - E(m)\right)^2\right\}, \tag{3.37}$$

where $m = \beta x_t^{-\alpha}$, x is the growth rate of consumption, k is the sample size, $\mu_x = E(lnx)$ and $\sigma_x^2 = Var(lnx)$.

If the actual standard deviation (variance) of the stochastic discount factor is less than the H-J minimum standard deviation (variance), then the asset pricing model is rejected, and the asset pricing for the equity market indicates that there is an equity premium puzzle. The fluctuation of the stochastic discount factor is closely related to the fluctuation of consumption growth rate and the relative risk aversion coefficient. When the fluctuation of consumption growth rate is small, the stochastic discount factor can be greatly affected only by setting a higher relative risk aversion coefficient to ensure that the actual variance of the random discount factor is greater than the H-J minimum variance. It can be seen that the H-J minimum variance bound is a test of asset pricing from different perspectives, and the method can enhance the persuasiveness of the empirical results.

3.3 Statistical Tests

In this part, Dickey-Fuller test and Durbin-Watson test are presented. Dickey-Fuller test is employed to examine the stationarity of input data, and Durbin-Watson statistic is used to test the autocorrelation of sample data.

3.3.1 Augmented Dickey-Fuller Test

Named for American statisticians David Dickey and Wayne Fuller who developed the test in 1979, the Dickey-Fuller test is used to determine whether a unit root, a feature of some stochastic processes that can cause problems in statistical inference, is present in an autoregressive (AR) model. Augmented Dickey-Fuller (ADF) test is an augmented version of the Dickey–Fuller (DF) test for a larger and more complicated set of time series models. It tests all the autocorrelation in the time series, using the same procedure as Dickey-Fuller test. There are two hypotheses for the test:

- the null hypothesis is that there is a unit root;
- the alternate is that the time series is stationary.

Consider a simple AR(1) model as follows,

$$y_t = \theta y_{t-1} + \epsilon_t, \tag{3.38}$$

where y_t is the variable of interest, *t* is the time,θ is a coefficient, and ϵ_t is the error term. A unit root is present if θ = *1*. The model would be non-stationary in this case.

The regression model can be formulated as

$$\Delta y_t = (\theta - 1)y_{t-1} + \epsilon_t = \delta y_{t-1} + \epsilon_t, \tag{3.39}$$

where Δ is the first difference operator. This model can be estimated and testing for a unit root is equivalent to testing $\delta = 0$ (where$\delta \equiv \theta - 1$).

The formula (3.38) can be extended to an AR(p) model, for example an AR(3) as follows,

$$y_t = \theta_1 y_{t-1} + \theta_2 y_{t-2} + \theta_3 y_{t-3} + \epsilon_t, \tag{3.40}$$

and

$$\Delta y_t = \delta y_{t-1} + c_1 \Delta y_{t-1} + c_2 \Delta y_{t-2} + \epsilon_t, \tag{3.41}$$

where $\delta = \theta_1 + \theta_2 + \theta_3 - 1$, $c_1 = -(\theta_2 + \theta_3)$ and $c_2 = -\theta_3$. The *t*-test for the null hypothesis ($\delta = 0$) is denoted the ADF test.

If the series y is stationary, then it has a tendency to return to a constant mean. That is to say, large values will tend to be followed by smaller values (negative changes), and small values followed by larger values (positive changes). Accordingly, the level of the series will be a significant predictor of next period's change, and will have a negative coefficient. On the other hand, if the series is integrated, then positive changes and negative changes will occur with probabilities that do not depend on the current level of the series, such as a random walk, where the current movement does not affect the future movement.

3.3.2 Durbin-Watson Test

Named after James Durbin and Geoffrey Watson who developed the test in 1950, the Durbin-Watson statistic is a test statistic used to detect the presence of autocorrelation at lag 1 in the residuals (prediction errors) from a regression analysis. Autocorrelation is the similarity of a time series over successive time intervals, indicating that the past residuals are connected with the current ones. It can lead to underestimates of the standard error and cause people to think predictors are significant while they are not. There are two assumptions that the errors are normally distributed with a mean of zero, and they are stationary. Two hypotheses for the Durbin-Watson test are shown as follows,

- the null hypothesis is that there is no first order autocorrelation;
- the alternative is first order correlation exists.

The test statistic is

$$d = \frac{\sum_{t=2}^{n}(e_t - e_{t-1})^2}{\sum_{t=1}^{n} e_t^2}, \tag{3.42}$$

where n is the number of observations, e_t is the residual. The Durbin Watson test reports a test statistic, with a value from 0 to 4. If the Durbin–Watson statistic is 2, there is no autocorrelation. If the result is substantially less than 2, there is evidence of positive serial correlation. If the result is substantially larger than 2, there is evidence of negative serial correlation. Usually the rule is that test statistic values in the range of 1.5 to 2.5 are relatively normal, while values outside of this range could be cause for concern.

4 Empirical Study of the Equity Premium Puzzle in China's Stock Market

This part is mainly based on the previous methodology. Because China's stock market has a very short history of 28 years starting from December 1990, monthly data are selected as a supplement for annual data to have a relatively large data set. The selected period is from December 1990 to March 2019.

4.1 Input Data Description and Adjustment

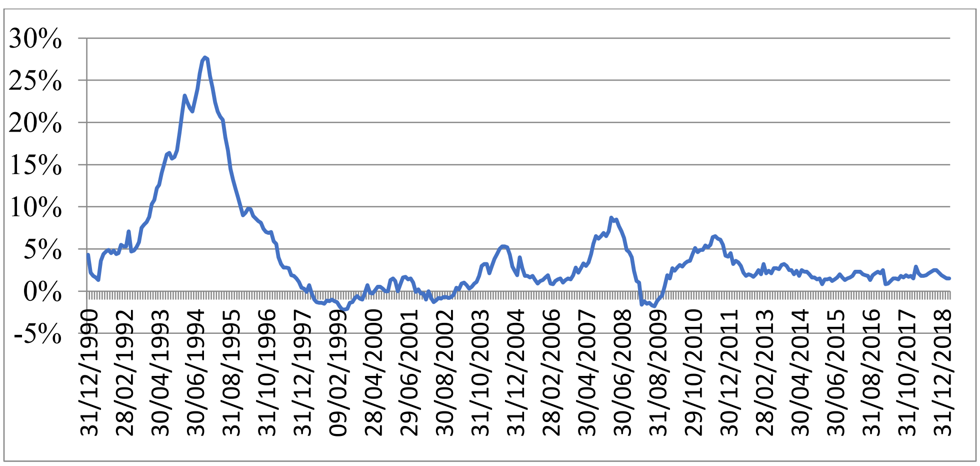
The basic data series are rate of return on stock, riskless rate of return, inflation rate and per capita consumption data. The yields of Shanghai Composite Index, Shenzhen Component Index and Shanghai and Shenzhen 300 Index are used as risky rate of return. The one-year deposit rate is used as the riskless rate of return. The total retail sales of consumer goods are selected as consumption data, and CPI is used as inflation data.

4.1.1 Inflation Data

The inflation data is first described since other data needs to be adjusted to inflation. CPI which measures the changes in price level of market basket of consumer goods and services is used to reflect inflation. CPI data are downloaded from China's National Bureau of Statistics. The trend of inflation data is shown in Figure 4.1. Detailed inflation data are shown in Annex I. The net inflation rate is obtained by the formula (4.1),

$$I_{t+1} = \frac{CPI_{t+1}}{CPI_t} - 1. \tag{4.1}$$

Figure 4.1 Inflation rate from December 1990 to March 2019



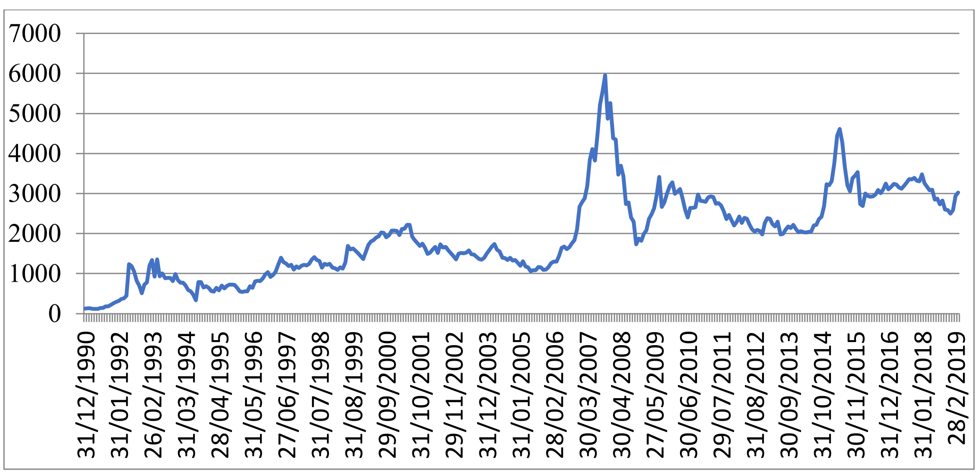
Source: China's National Bureau of Statistics

There is a decreasing trend of the inflation. The highest inflation rate was 27.7% appeared in October 1994. It is a result of housing reform which stimulates the housing market and domestic demand. The inflation rate is 1.5% in March 2019.

4.1.2 Stock Market Data

Several broad market indexes are chosen to represent the development of risky asset return in the market. The first index is the Shanghai Composite Index. It is the earliest market index in China and is one of the most important market indexes. Its sample stocks are all listed stocks on the Shanghai Stock Exchange, reflecting the changes in the price of listed stocks in the Shanghai stock market. It was officially released on December 19, 1990, and the base value was set at 100 points. Data from December 1990 to March 2019 are selected. The index trend is shown below in Figure 4.2.

Figure 4.2 Closing price of Shanghai Composite Index from Dec. 1990 to Mar. 2019

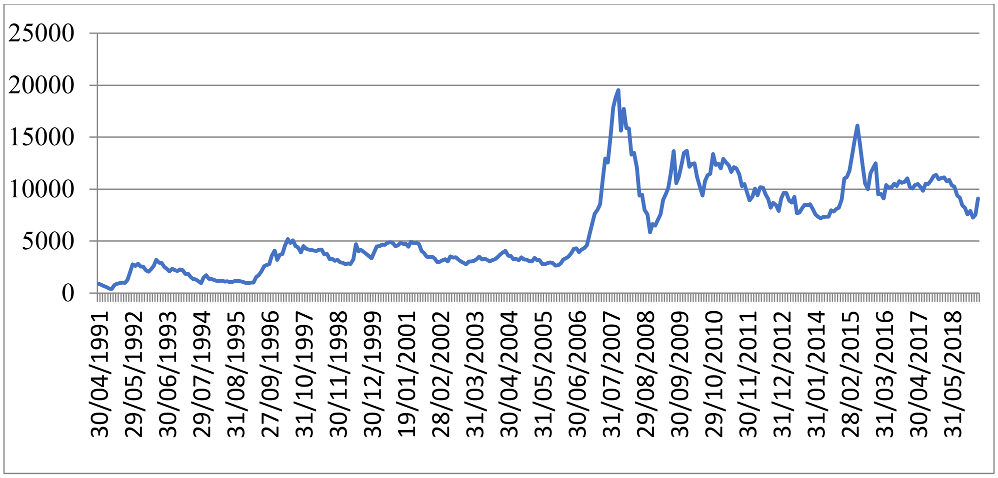


Source: Shanghai Stock Exchange

In the Figure 4.2, the highest peak reached at 5954.77 points on October 31, 2007 and it had its second peak at 4611.74 points in May 2015. The peak in 2007 is a result of the public listing of a large number of state-owned enterprises and entry of insurance and social security funds into the market. The decrease in 2008 is the consequence of global financial crisis and raise of interest rate by central bank. The second peak in 2015 is due to continuous cuts on interest rate and relaxation of security margin trading. In 2018, there was a down-turn pressure because of the US-China trade war and depreciation of domestic currency. However, at the beginning of 2019, it shows a rising trend above 3000 points.

The second index is Shenzhen Component Index. It is an index of 500 stocks traded at the SZSE. It was released on April 1991, and the basic value was set at 1000 points. Data from April 1991 to March 2019 are selected. The index is showed in Figure 4.3.

Figure 4.3 Closing price of Shenzhen Component Index from April 1991 to March 2019

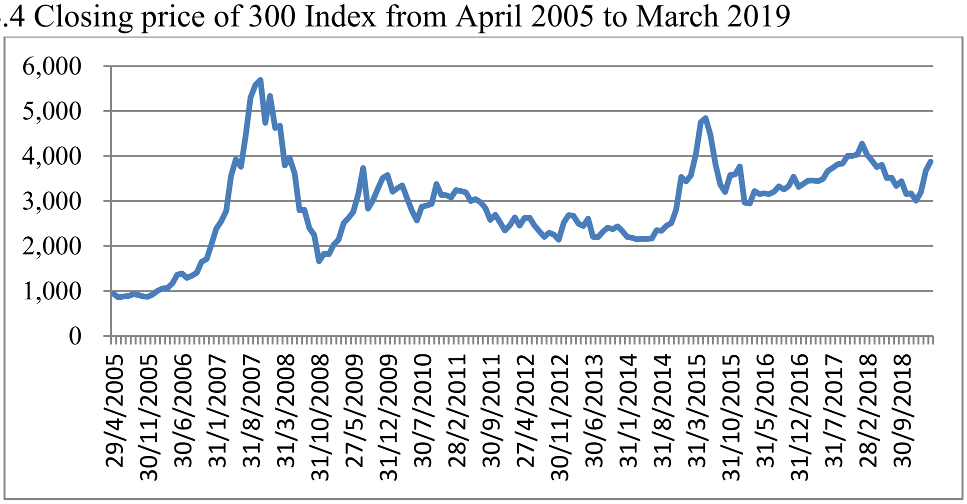


Source: Shenzhen Stock Exchange

In Figure 4.3, the Shenzhen Component Index shows a very similar trend as Shanghai Composite Index. The first peak reached at 19531.15 points on October 31, 2007. The second peak appeared at 16100.45 points in May 2015.

The last index is the Shanghai and Shenzhen 300 Index. It is a financial indicator published by the SHSE on April 8, 2005. The constituent stocks are the mainstream stocks with good market representation, high liquidity and active trading, reflecting the overall trend of the Shanghai and Shenzhen markets. Data from April 2005 to March 2019 are selected. The index is showed below in Figure 4.4.

Figure 4.4 Closing price of 300 Index from April 2005 to March 2019



Source: Shanghai Stock Exchange

The Shanghai Shenzhen 300 index copies the trends of Shanghai Composite Index and Shenzhen Component Index. It reached its peak at 5688.54 points on October 31, 2007, and had a second peak at 4840.83 points in May 2015.

The gross nominal capital return on the stock market can be calculated as follows,

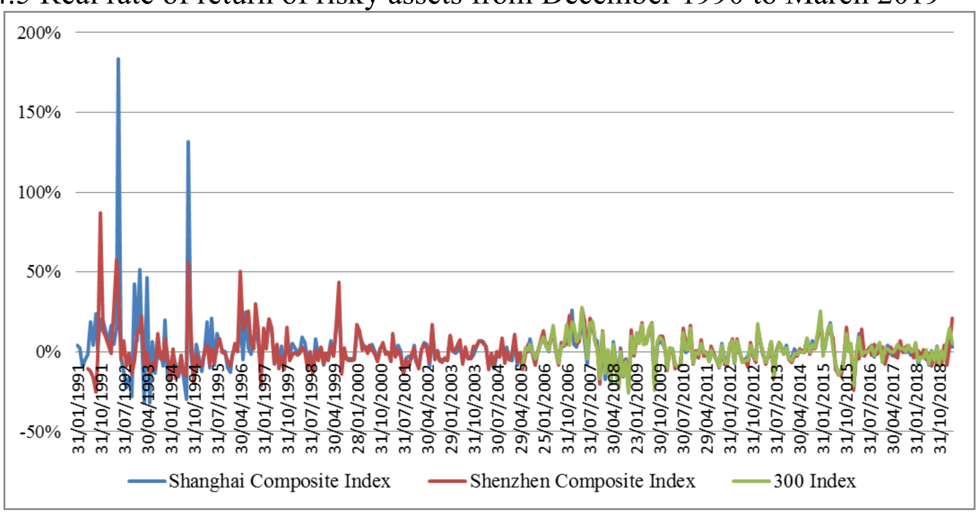
$$R_{e,t+1}^{nom} = \frac{p_{t+1}}{p_t} - 1. \tag{4.2}$$

In order to get the real capital return, we use the formula as follows,

$$R_{e,t+1}^{real} = \frac{p_{t+1}/p_t}{CPI_{t+1}/CPI_t} - 1. \tag{4.3}$$

The detailed data of real yield of risky assets are shown in Annex II. Figure 4.5 shows the trend of real rate of return of risky assets.

Figure 4.5 Real rate of return of risky assets from December 1990 to March 2019



Source: own elaboration

The rate of return on China's stock market was extremely fluctuated in early 1990s. The highest monthly rate of return achieved at 177% in May 1992. This is because there is no daily upper or lower limit on stock price. The rate of return became less fluctuated until the price limit was introduced in 1996.

4.1.3 Riskless Asset Return Data

In Mehra and Prescott's (1985) research on the equity premium of the US stock market, they used the yield of Treasury bill as the risk-free assets return. However, China's bond market develops late, and one-year government bonds are few. Deposit at bank can be considered as risk-free assets because most banks are state-owned and supported by central government and central bank. Also, the official riskless rate of return used by major financial institutions is the one-year deposit rate instead of government bond yield. Therefore, the one-year deposit rate is used as the indicator of the yield of risk-free assets. People's Bank of China (central bank) sometimes makes several changes about deposit rates within one year, thus it is necessary to calculate a weighted average deposit rate. For example, the deposit rate announced by central bank is 3% before November 22, 2014, and after that the rate is 2.75%. The weighted average deposit rate for 2014 is calculated as follows, (327/365·3%+38/365·2.75%) = 2.97%. A real risk-free rate of return can be obtained applying the formula (4.4),

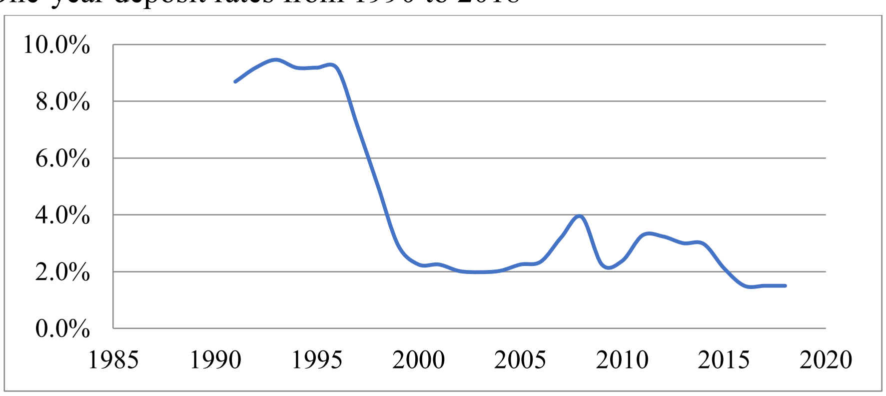
$$R_{f,t+1}^{real} = \frac{R_{f,t+1}^{nom}}{CPI_{t+1}/CPI_t}. \tag{4.4}$$

The equity premium is calculated as the difference between real risky rate of return and real riskless rate of return as follows,

$$EP_{t+1} = R_{e,t+1}^{real} - R_{f,t+1}^{real}. \tag{4.5}$$

Figure 4.6 shows the trend of weighted average one-year deposit rate from 1990 to 2018. The one-year deposit rates announced by the People's Bank of China and the annual weighted average deposit rates are shown in the Annex III.

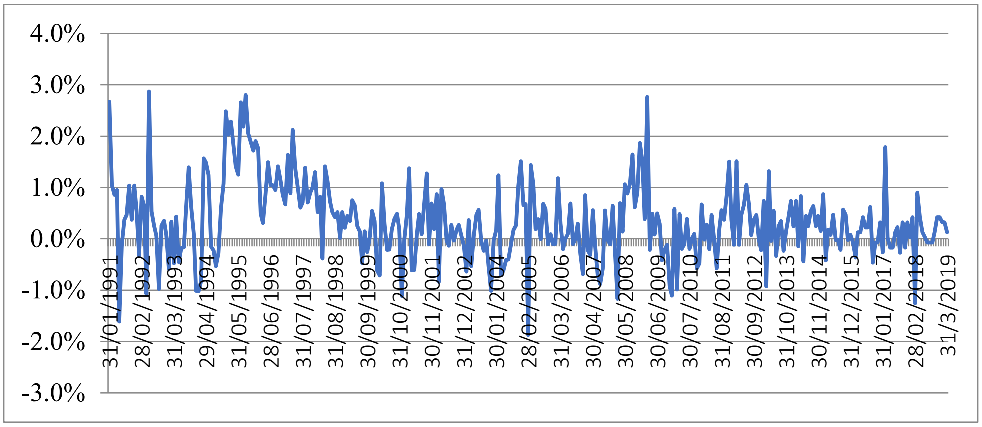
Figure 4.6 One-year deposit rates from 1990 to 2018



Source: own calculation

In the Figure 4.6, there is a decreasing trend of the deposit rate. The highest rate appeared in 1993 at 9.46%. The recent one-year deposit rate is 1.5%. The monthly real riskless rate of return is presented in Figure 4.7, and equity premium level is shown in Figure 4.8.

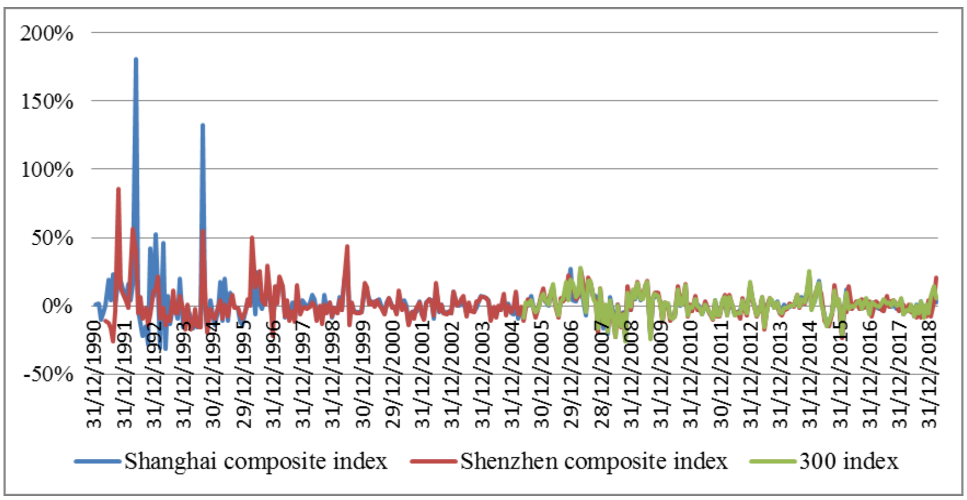
Figure 4.7 Real rate of return of riskless assets from January 1991 to March 2019



Source: own elaboration

The real rate of return is influenced a lot by inflation rate. The highest rate appeared at 3.04% in May 1992 due to relatively low inflation and high deposit rate.

Figure 4.8 Equity premiums from January 1991 to March 2019



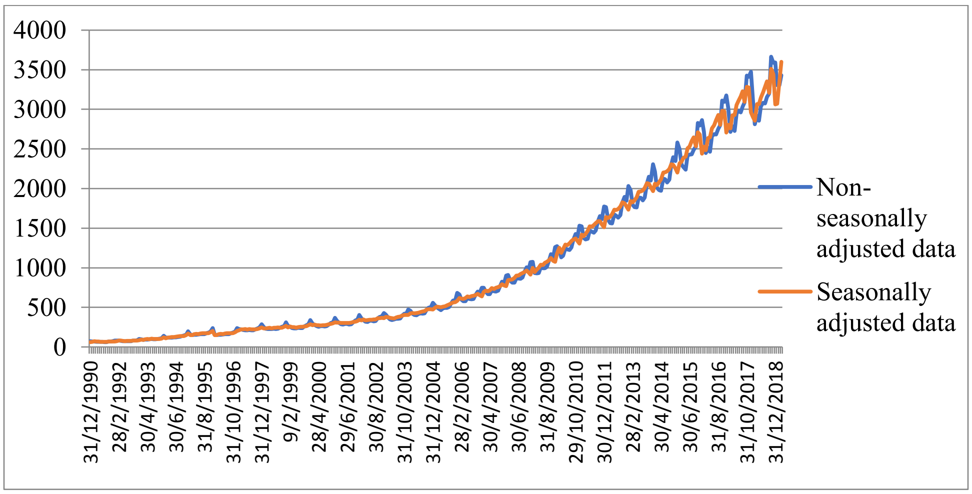
Source: own elaboration

In the Figure 4.8, it is obvious that the equity premium is mainly determined by the rate of return on stocks. The one-year deposit rate has little impact on the equity premium.

4.1.4 Per Capita Consumption Data

In order to better reflect the consumption of residents while meeting requirements of the standard model, a large number of foreign empirical studies adopt data which eliminates the consumption of durable goods and services. In this paper, data of total retail sales of consumer goods are used as the consumption data to reflect the consumption of Chinese residents. The data used are downloaded from China's National Bureau of Statistics. Detailed data can be found in Annex IV. The consumption data are not seasonally adjusted. It is necessary to eliminate the seasonality because seasonality increases the variance of consumption and influences the calculation of coefficient of relative risk aversion. Seasonally adjusted data are showed in Figure 4.9.

Figure 4.9 Total retail sales of consumer goods from 1990 to 2019 (billion RMB)

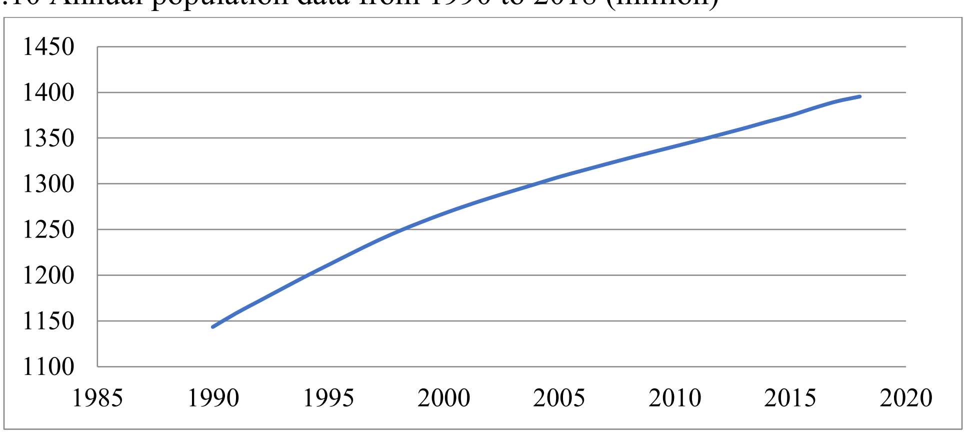


Source: China's National Bureau of Statistics, own elaboration

In Figure 4.9, there is an increasing trend of consumption and usually the highest amount of consumption appears at the end of the year because of the New Year festival. After removing the seasonality, the data become smoother with smaller fluctuations.

The monthly population data are needed to get the monthly per capita consumption data. But there is no monthly population data available, thus transformation of annual data to monthly data is needed. Annual population data are shown in Figure 4.10.

Figure 4.10 Annual population data from 1990 to 2018 (million)



Source: China's National Bureau of Statistics

The population is continuously growing with a slightly decreasing speed as shown in the Figure 4.10. Simple annual growth rate and exponential annual growth rate of population in each year are calculated to transform the annual population data to monthly data. The population data are shown in Annex V. The difference between the simple growth rate and exponential growth rate is very small, and average of these two growth rates is used to get the monthly population data.

The nominal per capita consumption data can be calculated by dividing the gross consumption with population. In order to get the real per capita consumption data, the original data needs to be adjusted to CPI using formula (4.6),

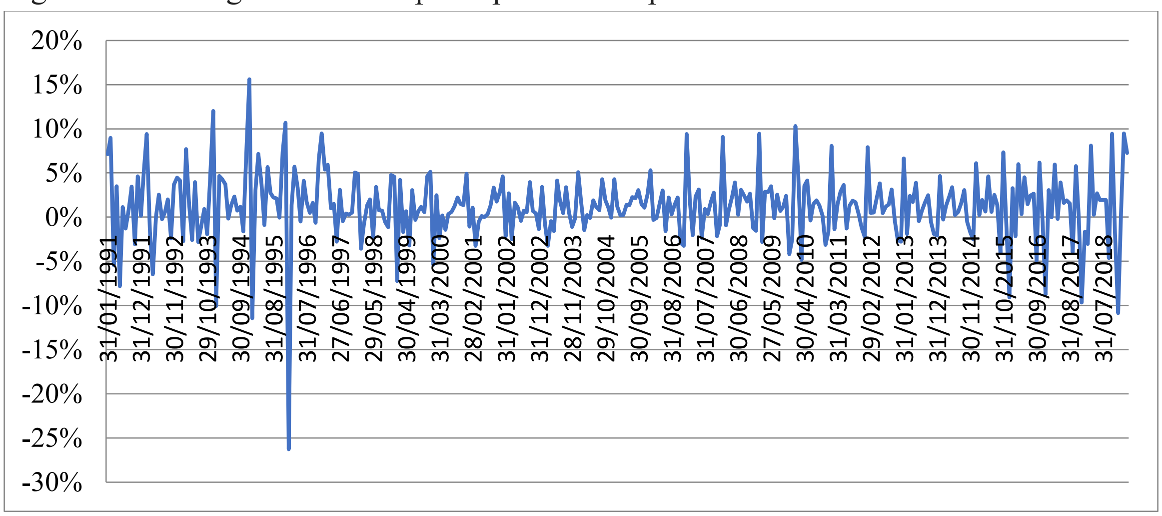
$$C_t^{real} = \frac{C_t^{nom}}{CPI_t}. \tag{4.6}$$

Thus, the real per capita consumption growth rate is calculated as follows,

$$x_t = \frac{C_{t+1}/C_t}{CPI_{t+1}/CPI_t} - 1, \tag{4.7}$$

where x_t is the growth rate of consumption at period t, C_t is the consumption at period t. The real growth rate of per capita consumption is shown in Figure 4.11.

Figure 4.11 Real growth rate of per capita consumption



Source: own elaboration

The highest real growth rate appeared at 11.2% in December 1993 and the lowest rate was -30.46% in January 1996.

4.2 Estimation of Equity Premium and Coefficient of Relative Risk Aversion

In this part, the historical equity premiums and theoretical equity premiums are calculated and compared with each other to see whether the equity premium puzzle exists. CRRA is calculated to see whether the value is within a reasonable theoretical range.

4.2.1 Calculation of Historical Equity Premium

Monthly data of Shanghai Composite Index and Shenzhen Component Index are equally divided into 9 sub-periods. Shanghai and Shenzhen 300 Index is divided into 5 periods to analyze the level of the equity premium in China's stock market and its trend in different time periods. The average monthly equity premium in Shanghai and Shenzhen stock markets are shown below in Tables 4.1, Table 4.2 and Table 4.3. EP_{sh}, EP_{sz} and EP_{300} are the equity premiums.

Table 4.1 Monthly equity premium level of Shanghai Composite Index

Time	Size	$R_{sh,t}$ (%)		$R_{f,t}$ (%)		EP_{sh} (%)	
		Mean	Stdev	Mean	Stdev	Mean	Stdev
Jan. 1991 - Mar. 2019	339	1.90	15.83	0.34	0.73	1.56	15.76

Source: own elaboration

Table 4.2 Monthly equity premium level of Shenzhen Composite Index

Time	Size	$R_{sz,t}$ (%)		$R_{f,t}$ (%)		EP_{sz} (%)	
		Mean	Stdev	Mean	Stdev	Mean	Stdev
May 1991 - Mar. 2019	335	1.33	11.97	0.33	0.72	1.00	11.97

Source: own elaboration

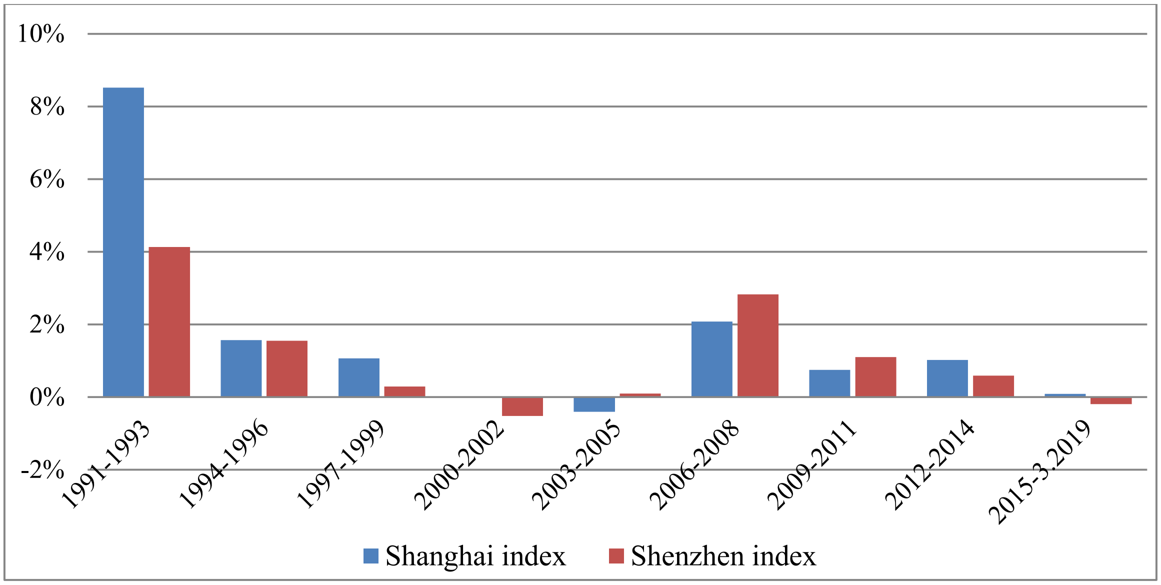
Table 4.3 Monthly equity premium level of Shanghai and Shenzhen 300 Index

Time	Size	$R_{300,t}$ (%)		$R_{f,t}$ (%)		EP_{300} (%)	
		Mean	Stdev	Mean	Stdev	Mean	Stdev
May 2005 - Mar. 2019	167	1.25	8.86	0.21	0.58	1.04	8.89

Source: own elaboration

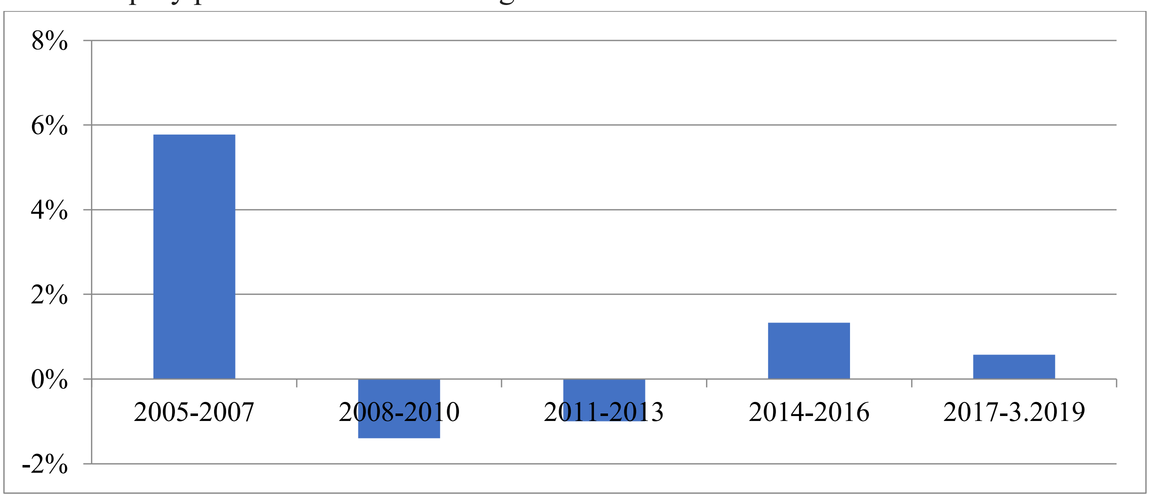
The riskless rates used for the three indexes are different because the release dates of those indexes are different. The Shanghai stock market has a monthly average equity premium of 1.56% which is higher than the equity premium in Shenzhen stock market, 1%. It is mainly because some extremely high premiums of Shanghai Composite Index appeared in 1992 and 1994 with a rate of 183.58% and 131.82% respectively. In December 1996, the Chinese government prescribed an upper limit on stock price that the rate of stock price increases couldn't exceed 10% in a trading day, making the market less volatile. The average equity premiums above are not high compared with some specific sub-periods showed below in the Figure 4.12 and Figure 4.13.

Figure 4.12 Equity premium levels of Shanghai Index and Shenzhen Index



Source: own elaboration

Figure 4.13 Equity premium levels of Shanghai and Shenzhen 300 Index



Source: own elaboration

During the period from 1991 to 1993, the equity premiums of Shanghai Composite Index and Shenzhen Component Index are very high, reaching 8.51% and 4.13% respectively. From 2005 to 2007 the equity premium of Shanghai and Shenzhen 300 Index is very high as well, reaching 5.78%. But some periods have very low or even negative equity premium levels due to low yield of stock. Thus, the period selection influences equity premium a lot. The detailed data are shown in Table 4.4, Table 4.5 and Table 4.6.

Table 4.4 Monthly data of Shanghai Composite Index in different periods

Time	Size	$R_{sh,t}$ (%)		$R_{f,t}$ (%)		EP_{sh} (%)	
		Mean	Stdev	Mean	Stdev	Mean	Stdev
Jan. 1991 - Mar. 2019	339	1.90	15.83	0.34	0.73	1.56	15.76
Jan. 1991- Dec. 1993	36	8.88	35.83	0.37	0.92	8.51	35.40
Jan. 1994 - Dec. 1996	36	2.60	25.46	1.03	0.90	1.57	25.67
Jan. 1997 - Dec. 1999	36	1.69	8.91	0.63	0.56	1.06	8.73
Jan. 2000 - Dec. 2002	36	0.14	6.03	0.16	0.58	-0.02	6.21
Jan. 2003 - Dec. 2005	36	-0.29	5.18	0.12	0.70	-0.41	5.32
Jan. 2006 - Dec. 2008	36	2.35	11.23	0.27	0.72	2.07	11.48
Jan. 2009 - Dec. 2011	36	0.89	7.69	0.14	0.71	0.75	7.67
Jan. 2012 - Dec. 2014	36	1.34	6.40	0.32	0.49	1.02	6.38
Jan. 2015 - Mar. 2019	51	0.22	7.01	0.13	0.43	0.09	6.92

Source: own elaboration

Table 4.5 Monthly data of Shenzhen Component Index in different periods

Time	Size	$R_{sz,t}$ (%)		$R_{f,t}$ (%)		EP_{sz} (%)	
		Mean	Stdev	Mean	Stdev	Mean	Stdev
May 1991 - Mar. 2019	335	1.33	11.97	0.33	0.72	1.00	11.97
May 1991 - Dec. 1993	32	4.37	22.54	0.24	0.84	4.13	22.38
Jan. 1994 - Dec. 1996	36	2.58	17.18	1.03	0.97	1.55	17.26
Jan. 1997 - Dec. 1999	36	0.91	11.40	0.63	0.56	0.28	11.24
Jan. 2000 - Dec. 2002	36	-0.35	6.74	0.16	0.58	-0.52	6.99
Jan. 2003 - Dec. 2005	36	0.21	5.79	0.12	0.70	0.09	5.93
Jan. 2006 - Dec. 2008	36	3.10	12.68	0.27	0.72	2.83	12.90
Jan. 2009 - Dec. 2011	36	1.24	9.39	0.14	0.71	1.10	9.38
Jan. 2012 - Dec. 2014	36	0.92	7.34	0.32	0.49	0.59	7.31
Jan. 2015 - Mar. 2019	51	-0.06	7.88	0.14	0.43	-0.20	7.83

Source: own elaboration

Table 4.6 Monthly data of Shanghai and Shenzhen 300 Index in different periods

Time	Size	$R_{300,t}$ (%)		$R_{f,t}$ (%)		EP_{300} (%)	
		Mean	Stdev	Mean	Stdev	Mean	Stdev
May 2005 - Mar. 2019	167	1.25	8.86	0.21	0.58	1.04	8.89
May 2005 - Dec. 2007	32	5.86	9.34	0.08	0.48	5.78	9.37
Jan. 2008 - Dec. 2010	36	-1.07	11.92	0.33	0.88	-1.40	12.00
Jan. 2011 - Dec. 2013	36	-0.67	6.53	0.33	0.56	-1.00	6.50
Jan. 2014 - Dec. 2016	36	1.56	9.10	0.23	0.35	1.33	9.04
Jan. 2017 - Mar. 2019	23	0.72	5.00	0.15	0.50	0.58	4.90

Source: own elaboration

Now annual data are used to calculate the annual equity premium. The results are shown below in Table 4.7.

Table 4.7 Annual equity premium level in China's stock market

	Mean (%)	Standard deviation (%)
$R_{sh,t}$	22.27	55.83
$R_{sz,t}$	23.93	73.43
R_{300}	24.83	65.85
R_f^{sh}	4.29	4.92
R_f^{sz}	4.10	4.91
R_f^{300}	2.57	2.68
EP_{sh}	17.97	54.43
EP_{sz}	19.83	70.12
EP_{300}	22.26	65.21

Source: own calculation

The annual equity premiums are very high in the table above. The EP of Shanghai stock market is 17.97%, EP of Shenzhen stock market is 19.83% and EP of 300 Index is 22.26%. The equity premium in China's stock market is much higher than the annual premium of the US stock market which is 6.18% calculated by Mehra and Prescott (1985). It is likely that the equity premium puzzle exists in China's stock market. Further study about the existence of equity premium puzzle will be conducted later.

4.2.2 Stationarity and Autocorrelation Test

Before the estimation of the equity premium and CRRA, it is better to test the stationarity of the rate of return and equity premium. It is not compulsory to test the stationarity of the data, but as Mehra (2008) stated that one of the major issues with estimation of the realized equity risk premium was that a very long time series of stationary returns. Also, he mentioned that the historically measured equity premium could be misleading if the risk premium has been non-stationary. This could result from changes in risk, or investors' risk attitude and diversification opportunities which may cause a reduction in the risk premium and changes in historical returns. Augmented Dickey Fuller (ADF) test is conducted in STATA for risky rate of return, riskless rate of return and equity premium. Here are the results shown below.

Figure 4.14 ADF test of rate of return in Shanghai stock market

Augmented Dickey-Fuller test for unit root   Number of obs   =   26

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-5.920	-4.371	-3.596	-3.238

MacKinnon approximate p-value for Z(t) = 0.0000

D.Riskyret~H	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Riskyretur~H						
L1.	-1.368882	.2312346	-5.92	0.000	-1.848433	-.8893311
LD.	.2768551	.1641975	1.69	0.106	-.0636698	.6173799
_trend	-.0106882	.0123955	-0.86	0.398	-.036395	.0150185
_cons	.3692674	.220451	1.68	0.108	-.0879201	.8264548

Source: own calculation

In the Figure 4.14, it shows *p*-value is 0, and *t*-calculated (-5.92) is lower than critical value (-4.371) at 1% significance level. Thus it rejects the null hypothesis, and it does not have unit root. The data is stationary.

Figure 4.15 ADF test of rate of return in Shenzhen stock market

Augmented Dickey-Fuller test for unit root   Number of obs   =   25

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-4.619	-4.380	-3.600	-3.240

MacKinnon approximate p-value for Z(t) = 0.0010

D.Riskyret~Z	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Riskyretur~Z						
L1.	-1.393515	.3016972	-4.62	0.000	-2.020929	-.7661016
LD.	.2993578	.1995854	1.50	0.149	-.1157027	.7144183
_trend	-.0187218	.0200104	-0.94	0.360	-.0603357	.0228921
_cons	.5631479	.3322646	1.69	0.105	-.1278341	1.25413

Source: own calculation

In the Figure 4.15, it shows *p*-value is 0.001 which is lower than significance level 1%, and *t*-calculated (-4.619) is lower than critical value (-4.38) at 1% significance level. Thus it rejects the null hypothesis, and it does not have unit root. The data is stationary.

Figure 4.16 ADF test of equity premium in Shanghai stock market

```
. dfuller SHEP , trend regress lag(1)

Augmented Dickey-Fuller test for unit root         Number of obs   =        26

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -5.840            -4.371            -3.596            -3.238
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000

------------------------------------------------------------------------------
D.SHEP       |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        SHEP |
         L1. |  -1.343396    .230034    -5.84   0.000    -1.820458    -.866335
         LD. |   .2605126   .1642512     1.59   0.127    -.0801237    .6011488
      _trend |  -.0066479   .0120316    -0.55   0.586    -.0315999     .018304
       _cons |   .2494594   .2088498     1.19   0.245    -.1836684    .6825873
------------------------------------------------------------------------------
```

Source: own calculation

In the Figure 4.16, it shows *p*-value is 0 which is lower than significance level 1%, and *t*-calculated (-5.84) is lower than critical value (-4.371) at 1% significance level. Thus it rejects the null hypothesis, and it does not have unit root. The data is stationary.

Figure 4.17 ADF test of equity premium in Shenzhen stock market

```
. dfuller SZEP , trend regress lag(1)

Augmented Dickey-Fuller test for unit root         Number of obs   =        25

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -4.670            -4.380            -3.600            -3.240
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0008

------------------------------------------------------------------------------
D.SZEP       |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        SZEP |
         L1. |  -1.420818   .3042565    -4.67   0.000    -2.053554   -.7880815
         LD. |   .3002584   .1994485     1.51   0.147    -.1145176    .7150343
      _trend |  -.0145755   .0194426    -0.75   0.462    -.0550086    .0258576
       _cons |   .4518634   .3179262     1.42   0.170    -.2093003    1.113027
```

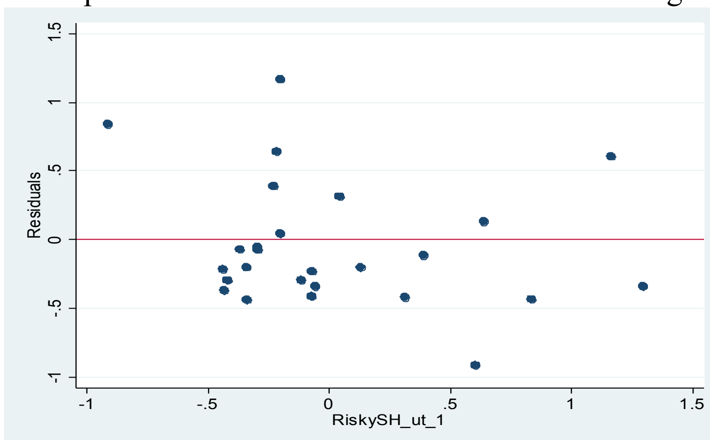
Source: own calculation

In the Figure 4.17, it shows *p*-value is 0.0008 which is lower than significance level 1%, and *t*-calculated (-4.67) is lower than critical value (-4.38) at 1% significance level. Thus it rejects the null hypothesis, and it does not have unit root. The data is stationary.

After the stationarity test, the test for autocorrelation is needed. Hanssan (2010) and Mehra (2008) estimated the EP using both arithmetic and geometric average, and they suggested that arithmetic was more proper for rates of return without autocorrelation.

Otherwise, the arithmetic mean will be biased as it overstates the rate of return. The autocorrelation of risky rate of return, riskless rate of return and per capita consumption growth rate will be examined. Both graphic description and statistical test are shown below.

Figure 4.18 Graphic description of autocorrelation of return rate in Shanghai market



Source: own calculation

No positive or negative autocorrelation is seen in the Figure 4.18 as the dots are distributed without a pattern. The result of Durbin-Watson test is shown in Figure 4.19.

Figure 4.19 Durbin-Watson test on rate of return in Shanghai stock market

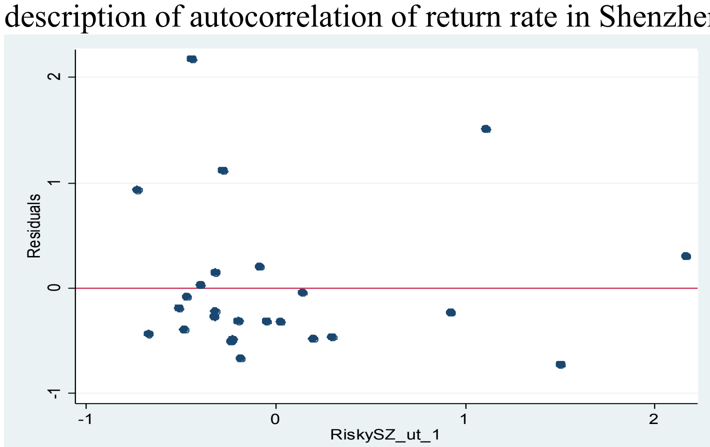
```
. dwstat

Durbin-Watson d-statistic(  2,    27) =  2.086443
```

Source: own calculation

The statistical result above indicates that there is no autocorrelation as the statistic value, 2.086 is close to 2 and null hypothesis is accepted.

Figure 4.20 Graphic description of autocorrelation of return rate in Shenzhen market



Source: own calculation

In Figure 4.20, no positive or negative autocorrelation is seen as the dots are distributed without a pattern. Durbin-Watson test is conducted and the result shown in

Figure 4.21 indicates that there is no autocorrelation as the statistic value, 1.984 is close to 2. Null hypothesis is accepted.

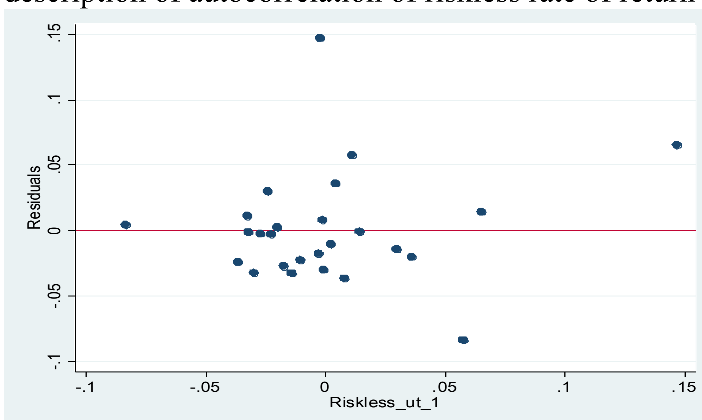
Figure 4.21 Durbin-Watson test on rate of return in Shenzhen stock market

```
. dwstat

Durbin-Watson d-statistic(  2,    26) =  1.983588
```

Source: own calculation

Figure 4.22 Graphic description of autocorrelation of riskless rate of return



Source: own calculation

No positive or negative autocorrelation is seen in the Figure 4.22 above as the dots are distributed without a pattern. Durbin-Watson test is conducted and the result shown in Figure 4.23 below.

Figure 4.23 Durbin-Watson test on rate of riskless rate of return

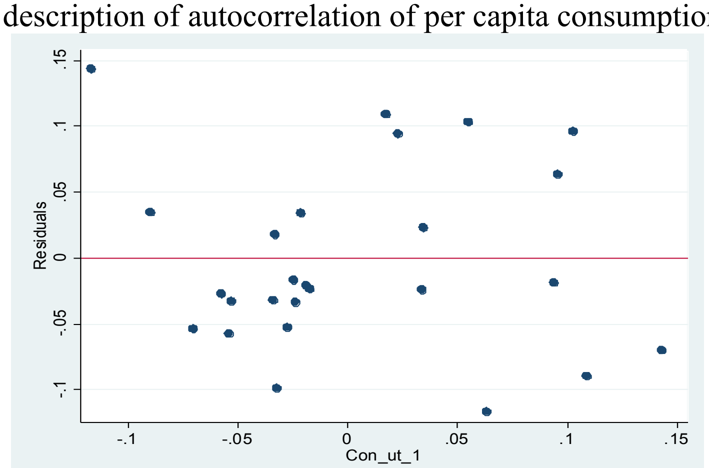
```
. dwstat

Durbin-Watson d-statistic(  2,    26) =  1.932959
```

Source: own calculation

The result in Figure 4.23 indicates that there is no autocorrelation as the statistic value, 1.933 is close to 2 and null hypothesis is accepted.

Figure 4.24 Graphic description of autocorrelation of per capita consumption growth rate



Source: own calculation

No positive or negative autocorrelation is seen in the Figure 4.24 above as the dots are distributed without a pattern. Durbin-Watson test is conducted and the result shown below in Figure 4.25.

Figure 4.25 Durbin-Watson test on per capita consumption growth rate

```
. dwstat

Durbin-Watson d-statistic(  2,    26) =  1.904517
```

Source: own calculation

The result in Figure 4.25 indicates that there is no autocorrelation as the statistic value, 1.905 is close to 2 and null hypothesis is accepted.

4.2.3 Estimation of Theoretical Equity Premium and CRRA

In Mehra and Prescott's model, α, the coefficient of relative risk aversion is assumed to be between 0 and 10. If α is greater than 10, the investors will be extremely risk averse. Lots of scholars have studied what the coefficient will be. Arrow (1971) came to the conclusion that CCRA with respect to wealth was almost constant, and he thought α should be around one. Research conducted by Friend and Blume (1975) suggested that α should be larger within the range of two. In the study of Kydland and Prescott (1982), it was found that α should be between one and two to imitate the variability of investment and consumption observed. All of those previous studies reach a consensus that a maximum value for α is 10. This restriction is very important as Mehra and Prescott (1985) stated that they found the results were essentially the same for very different consumption processes, provided that the mean and variances of growth rates equaled the historically observed values.

Chinese scholar Zhu (2003) studied the microeconomic behavior of investors and believed that the value of α was about 0.25 for Chinese consumers. The research conclusion of Chinese scholar Lin (2007) is that the α of Chinese consumers fall within a reasonable range of two. As for studies carried out by other scholars in China, such as Chen (2007), Du(2011), Wang(2004) and Zhang (2005), etc., although their sample selection, testing methods, and numerical results are not the same, they came to some similar conclusion that theoretically a reasonable α should fall within the range between 0 and 10, but empirically they got a α larger than 10, indicating the existence of equity premium puzzle in China.

Now, it comes to the calculation of theoretical equity premium under CCAPM. As mentioned before, the maximum reasonable value of α (CRRA) is ten. And the time discount factor β is less than 1 but close to 1. As α increases, the equity premium will increase as well. Thus, in order to get a large theoretical equity premium, it is assumed that α = 10 and β = 0.99. Applying formula (3.25), where $\mu_x = E(lnx)$ is the average continuously compounded growth rate of per capita consumption, and $\sigma_x^2 = Var(lnx)$ is the variance of continuously compounded growth rate of per capita consumption. μ_x can be obtained as follows,

$$\mu_x = E\{ln\left(\frac{C_{t+1}^{real}}{C_t^{real}}\right)\} \tag{4.8}$$

where C_t^{real} is real consumption at time *t,* and real consumption can be calculated according to previous formula (4.6). The results of μ_x and σ_x^2 can be found in Table 4.8 and Table 4.9.

Table 4.8 Annually continuously compounded growth rate of per capita consumption

Time	N	μ_x (%)	σ_x^2
1991-2018	28	13.03	0.00318

Source: own calculation

Table 4.9 Monthly continuously compounded growth rate of per capita consumption

time	N	μ_x (%)	σ_x^2
Jan.1991-Mar.2019	339	1.13	0.00151

Source: own calculation

Apply μ_x = 13.03%, and σ_x^2 = 0.00318 to formula (3.25) and formula (3.29), and it has

$$lnR_f = -ln\beta + \alpha\mu_x - \frac{1}{2}\alpha^2\sigma_x^2 = 1.14532, \tag{4.9}$$

and

$$lnE(R_e) = lnR_f + \alpha\sigma_x^2 = 1.17714. \tag{4.10}$$

The theoretical equity premium is calculated as $exp(lnR_f) - exp(lnR_e)$ =10.16%. The actual equity premiums in Shanghai stock market and Shenzhen stock market are 17.97% and 19.83% respectively (see Table 4.7). Both of the equity premiums are higher than the theoretical one, thus, the existence of equity premium puzzle is confirmed. Applying data in Table 4.9 to formula (3.25) and formula (3.29), the monthly theoretical equity premium can be calculated. The result is 1.54%, which is lower than the rate of return of Shanghai

Composite Index, but higher than the average monthly return rate of Shenzhen Component Index (see Table 4.1 and Table 4.2). It mainly results from the fact that the consumption growth rate in China is high and it fluctuates much with a variance higher than USA's market historical annual variance, causing higher equity premium.

Then the β or α is being changed to see how it will affect the equity premiums. α is set below 10. β is set lower than 1 and higher than 0.975 because β is assumed to be lower than 1 but close to 1. A sensitivity analysis is conducted to see how the equity premiums change with β and α. Table 4.10 and 4.11 show the results.

Table 4.10 Sensitivity analysis of monthly equity premiums with changing α and β

1.52%	1	2	3	4	5	6	7	8	9	10
0.975	0.15%	0.30%	0.45%	0.61%	0.77%	0.92%	1.08%	1.24%	1.39%	1.54%
0.977	0.15%	0.30%	0.45%	0.61%	0.77%	0.92%	1.08%	1.24%	1.39%	1.54%
0.979	0.15%	0.30%	0.45%	0.61%	0.76%	0.92%	1.08%	1.23%	1.39%	1.54%
0.981	0.15%	0.30%	0.45%	0.61%	0.76%	0.92%	1.08%	1.23%	1.38%	1.53%
0.983	0.15%	0.30%	0.45%	0.61%	0.76%	0.92%	1.07%	1.23%	1.38%	1.53%
0.985	0.15%	0.30%	0.45%	0.60%	0.76%	0.92%	1.07%	1.23%	1.38%	1.53%
0.987	0.15%	0.30%	0.45%	0.60%	0.76%	0.91%	1.07%	1.22%	1.38%	1.53%
0.989	0.15%	0.30%	0.45%	0.60%	0.76%	0.91%	1.07%	1.22%	1.37%	1.52%
0.991	0.15%	0.30%	0.45%	0.60%	0.76%	0.91%	1.06%	1.22%	1.37%	1.52%
0.993	0.15%	0.30%	0.45%	0.60%	0.75%	0.91%	1.06%	1.22%	1.37%	1.52%
0.995	0.15%	0.29%	0.45%	0.60%	0.75%	0.91%	1.06%	1.21%	1.36%	1.51%
0.997	0.15%	0.29%	0.44%	0.60%	0.75%	0.90%	1.06%	1.21%	1.36%	1.51%
0.999	0.15%	0.29%	0.44%	0.60%	0.75%	0.90%	1.06%	1.21%	1.36%	1.51%

Source: own calculation

Table 4.11 Sensitivity analysis of annual equity premiums with changing α and β

10.25%	1	2	3	4	5	6	7	8	9	10
0.975	0.37%	0.84%	1.43%	2.16%	3.03%	4.08%	5.32%	6.77%	8.46%	10.41%
0.977	0.37%	0.84%	1.43%	2.15%	3.03%	4.07%	5.31%	6.76%	8.45%	10.39%
0.979	0.37%	0.84%	1.43%	2.15%	3.02%	4.06%	5.30%	6.75%	8.43%	10.37%
0.981	0.37%	0.84%	1.42%	2.14%	3.01%	4.06%	5.29%	6.73%	8.41%	10.35%
0.983	0.37%	0.84%	1.42%	2.14%	3.01%	4.05%	5.28%	6.72%	8.40%	10.33%
0.985	0.37%	0.84%	1.42%	2.13%	3.00%	4.04%	5.27%	6.71%	8.38%	10.31%
0.987	0.37%	0.83%	1.42%	2.13%	3.00%	4.03%	5.26%	6.69%	8.36%	10.28%
0.989	0.37%	0.83%	1.41%	2.13%	2.99%	4.02%	5.24%	6.68%	8.34%	10.26%
0.991	0.37%	0.83%	1.41%	2.12%	2.98%	4.01%	5.23%	6.66%	8.33%	10.24%
0.993	0.36%	0.83%	1.41%	2.12%	2.98%	4.01%	5.22%	6.65%	8.31%	10.22%
0.995	0.36%	0.83%	1.40%	2.11%	2.97%	4.00%	5.21%	6.64%	8.29%	10.20%
0.997	0.36%	0.83%	1.40%	2.11%	2.97%	3.99%	5.20%	6.62%	8.28%	10.18%
0.999	0.36%	0.82%	1.40%	2.10%	2.96%	3.98%	5.19%	6.61%	8.26%	10.16%

Source: own calculation

In the Table 4.10 and Table 4.11, the first row represents the CRRA and the first column represents β. It is indicated that the increasing α results in an increasing equity premium, while the increasing β causes a lower equity premium. It is because β measures how impatient households are to consume. If the β is big, people are less impatient, with a weak preference for consumption now versus consumption in the future. They are willing to delay the current consumption and make investment. Thus, the equity premium they required is less than those people who are more impatient.

The highest theoretical annual equity premium obtained is 10.41% (see Table 4.11), when $\beta = 0.975$ and $\alpha = 10$. The result is lower than the actual average equity premium in Shanghai and Shenzhen stock market (17.97% for SH and 19.83% for SZ, see Table 4.7) The highest theoretical monthly equity premium obtained is 1.54% (see Table 4.10), which are lower than the actual equity premium in Shanghai stock market but higher than equity premium in Shenzhen stock market (1.56% for SH and 1.00% for SZ, see Table 4.1 and Table 4.2). Using the reasonable theoretical parameters, a theoretical equity premium which is higher than the actual equity premium is not likely to be obtained, indicating the existence of small equity premium puzzle in China.

Furthermore, the historical stock rate of return and riskless rate of return are employed to calculate the CRRA to see whether the actual one is higher than the theoretical one. If the actual CRRA is higher than the maximum theoretical CRRA, an equity premium puzzle exists.

Applying the average rate of return on stock, riskless rate of return (see Table 4.7) and variance of continuously compounded growth rate of consumption (see Table 4.8) to formula (3.30), the CRRA can be obtained as follows,

$$\alpha = \frac{lnE\left(R_{e,sh}\right) - lnE\left(R_{f,sh}\right)}{\sigma_x^2} = 49.981, \tag{4.11}$$

and

$$\alpha = \frac{lnE\left(R_{e,sz}\right) - lnE\left(R_{f,sz}\right)}{\sigma_x^2} = 54.806. \tag{4.12}$$

The CRRA calculated is 49.981 and 54.806 for Shanghai stock market and Shenzhen stock market respectively. The CRRAs calculated are much higher than the theoretical maximum CRRA 10, thus, there is evidence for equity premium puzzle.

4.3 Hansen-Jagannathan Bound Test

The minimum variance bound sets a lower bound on the theoretical variance of a stochastic discount factor. The minimum variance of the stochastic discount factor is estimated from the historical data on the stock market. If the stochastic discount factor is estimated based on the consumption utility function, and its actual variance (standard deviation) is less than the theoretical minimum variation (standard deviation), it will have the indication that there is an equity premium puzzle in the market and assets can't be reasonably priced by CCAPM.

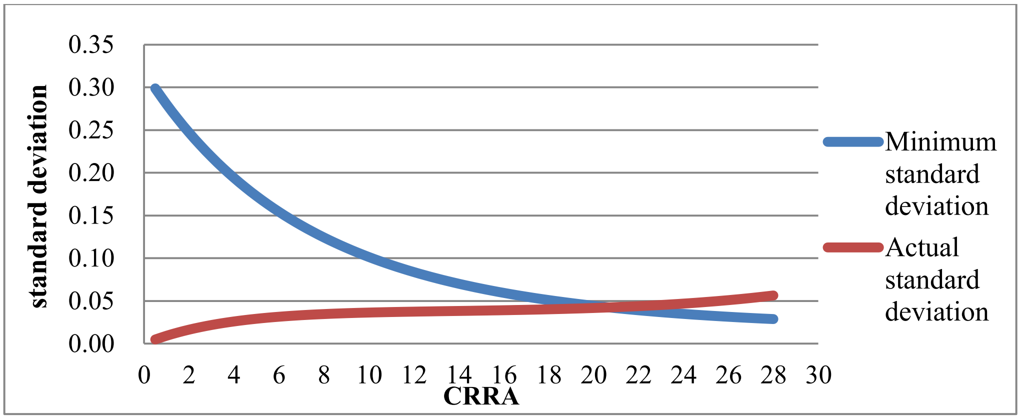
There are close relations between CCAPM and Hansen-Jagannathan bound test. Hansen-Jagannathan bound test can be used to test the validity of any asset pricing model. The theory behind is that the ratio of the standard deviation of a stochastic discount factor to its mean exceeds the Sharpe ratio attained by any portfolio. In this thesis, Hansen-Jagannathan bound is used to test the validity of application of CCAPM to China's stock market. It examines whether the CCAPM is valid in explaining the equity premium in China's market. If the result is that standard deviation of a stochastic discount factor to its mean does not exceed the Sharpe ratio, the asset pricing model will be rejected. It further confirms the existence of equity premium puzzle as the standard pricing model fails to explain the equity premium level in the market.

First the theoretical minimum variance of the stochastic discount factor is estimated. Given a constant subjective time discount factor β and changing CRRA α, several series of stochastic discount factors and the variances of them will be calculated. By changing the CRRA, it can be seen in what range the actual variance of stochastic discount factor is higher than the theoretical minimum value. That is to say, what the CRRA will be that makes the asset pricing model reasonably explain the equity premium; also by setting the time discount factor at different level, it can be seen the changes in CRRA to make actual variance (standard deviation) surpass the minimum bound.

Both minimum variance (standard deviation) of SDF and actual variance (standard deviation) of SDF can be calculated according formula (3.33) and formula (3.35). β is set at different value of 0.99, 0.95 and 0.9. Usually β is set above 0.95 in Merha's study (2008), but here a lower value is set. The slightly bigger difference will make the changes of CRRA more visible.

Keeping β constant at 0.99, and the actual standard deviation of SDF and the minimum theoretical standard deviation of SDF are presented in Figure 4.25. It also shows the CRRA which satisfies the minimum standard deviation in both Shanghai (SH) stock market and Shenzhen (SZ) stock market.

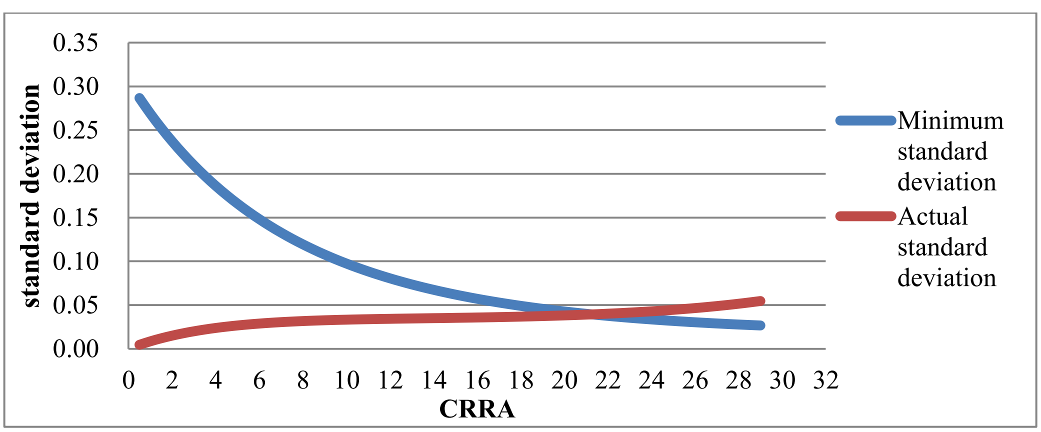
Figure 4.25 Minimum standard deviation and actual standard deviation (SH) (β = 0.99)



Source: own calculation

In the Figure 4.25 above, the horizontal axis represents the CRRA and the vertical axis represents the standard deviation. Keeping β constant at 0.99, when the CRRA is set at 20.5, the actual standard deviation is 0.0423. It is lower than the minimum standard deviation, 0.0429. When the CRRA increases to 21, the actual standard deviation is 0.0428 which is higher than the minimum standard deviation 0.0416. If the CRRA is higher than 21, the actual standard deviation will always be higher than the minimum standard deviation. However, the CRRA is higher than the theoretical reasonable range of CRRA between 0 and 10 given by the CCAPM. Thus, the equity premium puzzle exists.

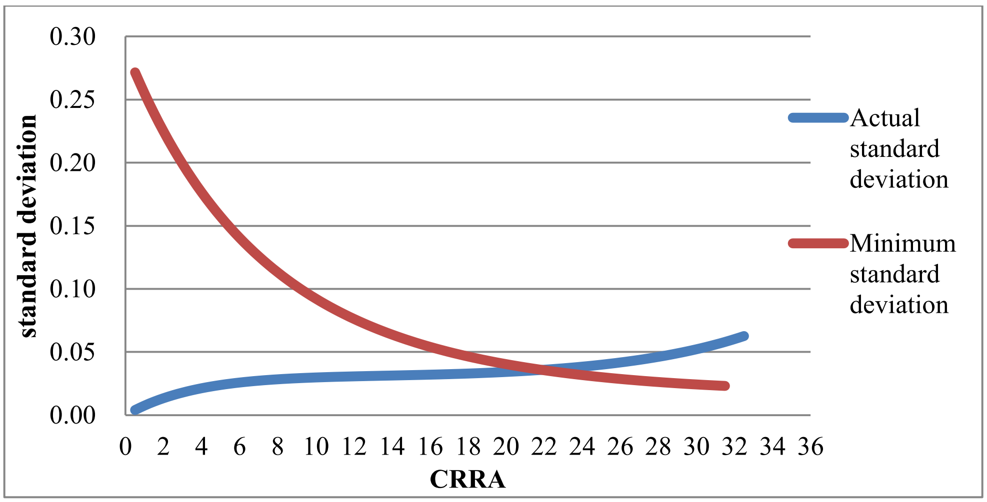
Figure 4.26 Minimum standard deviation and actual standard deviation (SH) (β = 0.95)



Source: own calculation

Keeping β constant at 0.95, the threshold of CRRA making the actual standard deviation higher than the minimum standard deviation is between 21 and 21.5. When the CRRA is 21, the minimum standard deviation is 0.0399 which is higher than the actual standard deviation 0.0390. When the CRRA increases to 21.5, the minimum standard deviation is approximately 0.0387 which is lower than the actual standard deviation 0.0395. The CRRA is higher than the theoretical reasonable range of CRRA lying between 0 and 10. Thus, the equity premium exists in Shanghai stock market.

Figure 4.27 Minimum standard deviation and actual standard deviation (SH) (β = 0.90)

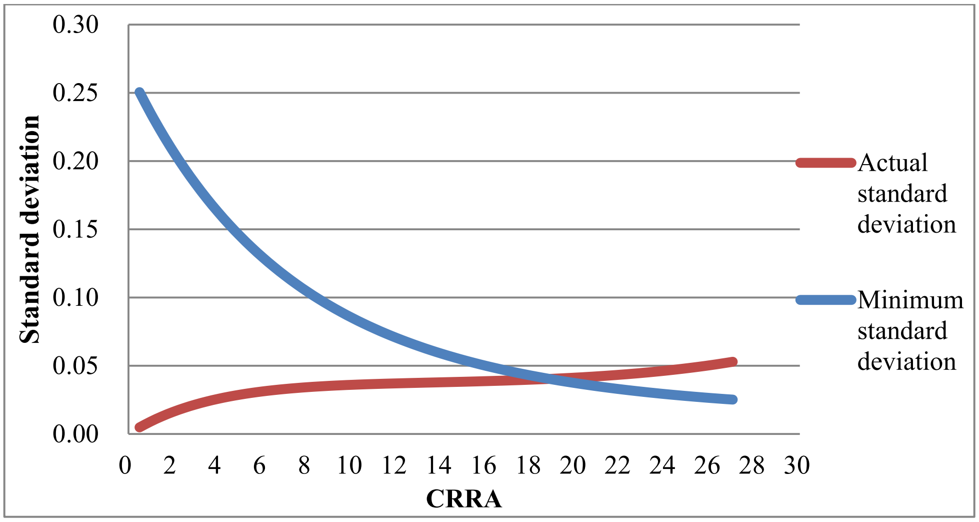


Source: own calculation

Keeping β constant at 0.9, the threshold of CRRA making the actual standard deviation higher than the minimum standard deviation is between 21.5 and 22. When the CRRA is 21.5, the minimum standard deviation is 0.0367 which is higher than the actual standard deviation 0.0355. When the CRRA increases to 22, the minimum standard deviation is approximately 0.0356 which is lower than the actual standard deviation 0.0360. The CRRA is higher than the theoretical reasonable range of CRRA lying between 0 and 10. Thus, the equity premium exists in Shanghai stock market.

In the Figure 4.28, Figure 4.29 and Figure 4.30, it shows the situation in Shenzhen stock market, and the results are similar to Shanghai stock market. Equity premium puzzle also exists in Shenzhen stock market as the actual standard deviation is lower than the minimum standard deviation within the theoretical reasonable CRRA ranging from 0 to 10.

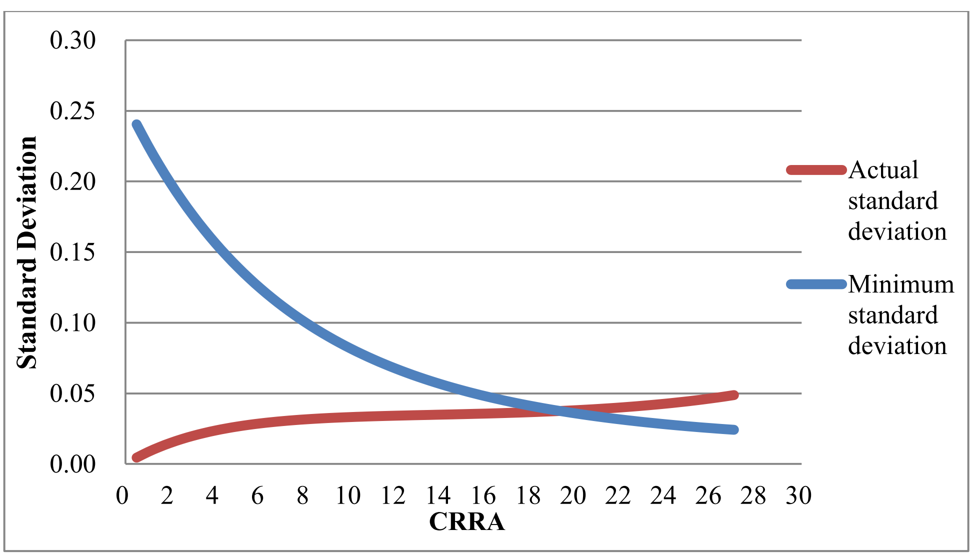
Figure 4.28 Minimum standard deviation and actual standard deviation (SZ) (β = 0.99)



Source: own elaboration

Keeping β constant at 0.99, the threshold of CRRA making the actual standard deviation higher than the minimum standard deviation is between 18.5 and 19. When the CRRA is 18.5, the minimum standard deviation is 0.0413 which is higher than the actual standard deviation 0.0402. When the CRRA increases to 19, the minimum standard deviation is approximately 0.0399 which is lower than the actual standard deviation 0.0405. The CRRA is higher than the theoretical reasonable range of CRRA between 0 and 10. Thus, the equity premium exists in Shenzhen stock market.

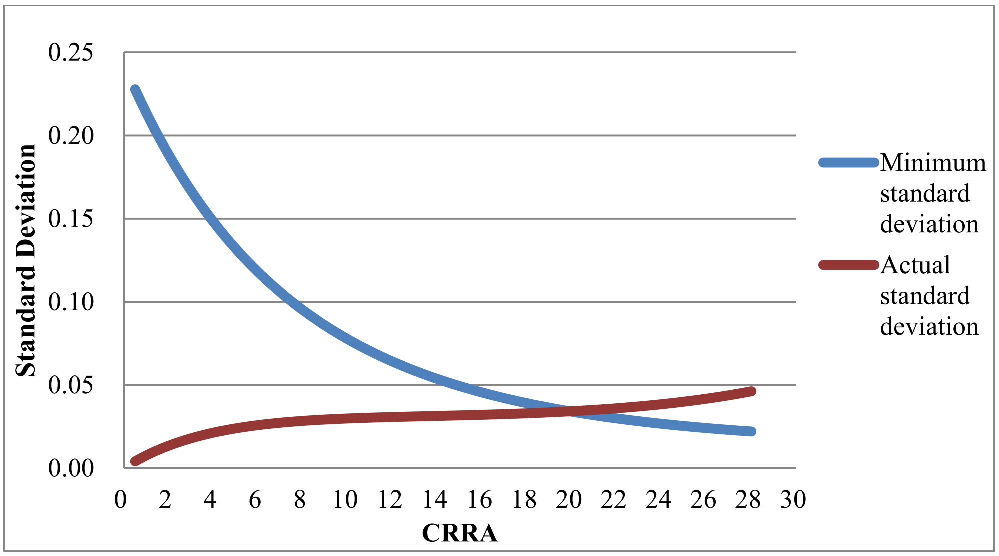
Figure 4.29 Minimum standard deviation and actual standard deviation (SZ) (β = 0.95)



Source: own calculation

Keeping β constant at 0.95, the threshold of CRRA making the actual standard deviation higher than the minimum standard deviation is between 19 and 19.5. When the CRRA is 19, the minimum standard deviation is 0.0383 which is higher than the actual standard deviation 0.0374. When the CRRA increases to 19.5, the minimum standard deviation is approximately 0.0369 which is lower than the actual standard deviation 0.0377. The CRRA is higher than the theoretical reasonable range of CRRA between 0 and 10. Thus, the equity premium exists in Shenzhen stock market.

Figure 4.30 Minimum standard deviation and actual standard deviation (SZ) (β = 0.90)



Source: own calculation

Keeping β constant at 0.9, the threshold of CRRA making the actual standard deviation higher than the minimum standard deviation is between 19.5 and 20. When the CRRA is 19.5, the minimum standard deviation is 0.0350 which is higher than the actual standard deviation 0.0338. When the CRRA increases to 20, the minimum standard deviation is approximately 0.0338 which is lower than the actual standard deviation 0.0342. Thus, when CRRA is equal or higher than 20, the assets can be reasonably priced. The CRRA is higher than the theoretical reasonable range of CRRA between 0 and 10 given by the CCAPM. Thus, the equity premium puzzle exists in Shenzhen stock market.

As the time discount factor decreases, the threshold of CRRA increases in order to get an actual standard deviation higher than the theoretical minimum standard deviation. But the increasing speed of CRRA is very slow in Shenzhen market which rises from 18.5 to 19 and 19.5 when β decreases from 0.99 to 0.95 and 0.9. Even though we see a negative relationship between the CRRA and time discount factor, but there isn’t any real economic relations between them. The time discount factor measures the consumers' patience with time, while the CRRA measures the risk aversion of consumers under different economic conditions. The two have no negative correlation in economic sense as stated by Mehra (2008). It can’t be said that a person with a poor tolerance of time must be more risk-averse than someone with a high degree of time tolerance. However, in our estimation process, the reason why the two seem to have a negative correlation is the expression of the stochastic discount factor. The stochastic discount factor is positively correlated with the time discount factor and negatively correlated with the relative risk aversion coefficient.

5 Conclusion

This thesis is focused on the study of equity premium puzzle (EPP) in China's stock market and comes to the conclusion that the EPP exists in China. The result is in line with the empirical results found by scholars, for example Du (2008), Wang (2005) and Lun et. al (2010).

Firstly, estimation method of CRRA and equity premium (EP) based on CCAPM is used. Using the data from 1990 to 2018, the annual EP estimated in Shanghai stock market and Shenzhen stock market are 22.27% and 23.93% respectively. The risk free rates are 4.29% (SH) and 4.1% (SZ). The difference of those two risk-free rates results from the later issuance of Shenzhen Component Index. The actual EP in Shanghai stock market and Shenzhen stock market are 17.97% and 19.83% respectively. The EP in China is much higher than the historical EP in the United States (6.18%), United Kingdom (6.1%), Japan (9.8%), Germany (9.1%), France (9.3%), and India (11.3%) provided in Mehra's book (Mehra, 2008). Both of the EPs are higher than the theoretical maximum equity premium, 10.41%. Thus, there is a presence of EPP in China's stock market. Moreover, the CRRAs calculated are 49.98 and 54.81 for Shanghai stock market and Shenzhen stock market respectively. They are higher than the theoretical maximum value of CRRA which is 10.

Next, Hansen-Jagannathan bound test is employed, and the result confirms the existence of EPP in China's stock market. Given the CRRA under 10, the calculated actual variance (standard deviation) of stochastic discount factor is always lower than the theoretical minimum variance (standard deviation), rejecting the valid application of CCAPM to China's stock market. CCAPM can't reasonably explain the equity premium level in China. Thus, it verifies the presence of EPP in China's stock market.

Furthermore, monthly data are used, and the overall period from December 1990 to March 2019 is divided into several sub-periods. Comparison between the EPs in different sub-periods is conducted, and the difference between those EPs is large. Therefore, it indicates the time-varying characteristics of EP.

The EP is a crucial input into financial decisions such as asset allocation, capital budgeting and planning for retirement, and the presence of EPP in China has some implications for Chinese investors and policy makers.

First, from the perspective of resource allocation, the equity premium puzzle means that the economic cost of systemic risk is high, and economic fluctuations or recession will lead to huge losses in social and economic welfare. From this perspective, it is very important to maintain a stable operation of the macro economy. For the time being, how to avoid the ups and downs of the stock market and how to achieve a stable operation of the stock market become the top priority of Chinese government decision-making.

Second, the equity premium puzzle will lead to short-termism of corporate investment. Short-termism refers to an excessive focus on short-term results at the expense of long-term interests. Short-term performance pressures on investors can result in an excessive focus on their quarterly earnings, with less attention paid to strategy, fundamentals and long-term value creation. The short-termism has a negative impact on the long-term stable development of the national economy, and may also lead to a decline in the overall welfare level of the national economy. Therefore, how to arrange appropriate institutional or economic policies to guide the investment behavior of enterprises and ensure the sustainable and stable development of the national economy becomes very meaningful.

Third, the equity premium puzzle has important implications for China's social security fund management. Established in August 2000, China’s social security fund has a very short history, and its foundation is relatively weak. It is very beneficial for the social security fund to distribute some social security funds to the stock market with long-term diversified portfolio as it will increase the yield of social security funds especially when the premium is high. In addition, the entry of social security funds as public assets into the stock market can also bring some welfare benefits such as lowering the equity premium, which naturally reduces the economic cost of risk and reduces investment short-sightedness. The impact of the equity premium on the allocation of social security funds on bonds and equity assets is also significant.

Lastly, the equity premium puzzle also has an important impact on individual investment decisions. The existence of large equity premium means that the long-term return of stocks is much higher than the yield of bonds, so investors are more likely to transfer the wealth invested in bonds or other assets into the stock market as they can get higher returns.

Bibliography

a) Professional books

[1] CARL, E. Walter and Fraser, J. T. HOWIE. *Privatizing China: The Stock Markets and Their Role in Corporate Reform.* New Jersey: John Wiley & Sons, 2003. ISBN 978-0470821206.

[2] EDWIN, T. Burton and Sunit, N. SHAH. *Behavioral Finance: Understanding the Social, Cognitive, and Economic Debates*. New Jersey: John Wiley & Sons, 2013. ISBN 978-1119203605.

[3] MEHRA, Rajnish. *Handbook of the Equity Risk Premium.* Amsterdam: Elsevier Science, 2008. ISBN 978-0444508997.

b) An article in a journal

[1] ABEL, Andrew B. Asset Prices under Habit Formation and Catching up with the Jonese.s *The American Economic Review*. May, 1990, Vol. 80, No. 2.

[2] AROURI, Mohamed El Hedi, Frederic, TEULON and Christophe, RAULT. Equity Risk Premium and Regional Integration. *CESifo Working Paper: Monetary Policy and International Finance,* 2013.

[3] BAETJE, Fabian and Lukas, MENKHOFF. Equity Premium Prediction: Are Economic and Technical Indicators Instable. *Kiel Working Paper*, No. 1987, 2015.

[4] BANSAL, Ravi and Amir, YARON. Risks for the Long Run: A Potential Resolution of Asset Pricing Puzzles. *NBER Working Paper No. 8059*, December 2000.

[5] BENARTZI, Shlomo and Richard, THALER. Myopic Loss Aversion and the Equity Premium Puzzle. *The Quarterly Journal of Economics*. 1995, Vol. 110, Issue 1.

[6] BREEDEN, T. Douglas. An Intertemporal Asset Pricing Model with Stochastic Consumption and Investment Opportunities. *Journal of Financial Economics.* September 1979, Vol 7, Issue 3, p. 265-296.

[7] BROWN, J. Stephen, William, N. GOETZMANN and Stephen, A. ROSS. Survival. *NYU Working Paper No. FIN-94-02135*, March 1995.

[8] CAMPBELL, Y. John and John, H. COCHRANE. By Force of Habit: A Consumption-Based Explanation of Aggregate Stock Market Behavior. *Working Paper* No. 4995, 1995.

[9] CONSTANTNIDES, George. Habit Formation: A Resolution of the Equity Premium Puzzle. *Journal of Political Economy*. 1990, Vol. 98, Issue 3.

[10] CONSTANTNIDES, George, John, B. DONALDSON and Rajnish, MEHRA. Junior Can't Borrow: A New Perspective on the Equity Premium Puzzle. *The Quarterly Journal of Economics.* 2002, Vol. 117, Issue 1.

[11] CHEN, Langnan. Risk Premium and Bubble Measurement in China's Stock Market. *Report of the research project of Shanghai Stock Exchange,* September 2002.

[12] CHEN, Xuesheng. Research on Three-factor Time-varying Risk Premium Model of China's Stock Market. S*outhern Economy,* Apr. 2007.

[13] DAMODARAN, Aswath. Equity Risk Premiums (ERP): Determinants, Estimation and Implications. *Stern School of Business*, 2008.

[14] DU, Haifeng and Ting, WANG. Equity Premium Research. *Economic Forum*, 2011.

[15] DENG, Xuebin. The Epstein-Zin Utility Function Model Based on Habit Formation and the Equity Premium Puzzle: Evidence from China's A-Share Market. *Journal of Jinan University (Philosophy and Social Sciences),* December 2012.

[16] EPSTEIN, Lawrence and Stanley, ZIN. Substitution Risk Aversion and the Temporal Behavior of Consumption and Asset Returns: A Theoretical Framework. *Econometrica*, 1987.

[17] EPSTEIN, Lawrence and Stanley, ZIN. Substitution Risk Aversion and the Temporal Behavior of Consumption and Asset Returns: An Empirical Investigation. *Journal of Political Economy*, 1991.

[18] EDELSTEIN, Robert and Konstantin, MAGIN. The Equity Risk Premium Puzzle: A Resolution: The Case for Real Estate. *Risk Management Research UC Berkeley*, 2012.

[19] FAMA, F. Eugene and Kenneth, R. FRENCH. Business Condition and Expected Return on Stocks and Bonds. *The Journal of Financial Economics*, 1989.

[20] FAMA, F. Eugene and Kenneth, R. FRENCH. The Equity Premium. *The Journal of Finance*. April 2002, Vol.VII, No.2.

[21] FAMA, F. Eugene and Kenneth, R. FRENCH. The Capital Asset Pricing Model: Theory and Evidence. *Journal of Economic Perspectives*, 2004, Vol.18, No.3.

[22] FAVILUKIS, Jack. Inequality, Stock Market Participation, and the Equity Premium. *Journal of Financial Economics.* March 2013, Vol 107, Issue 3.

[23] FRIEND, Irwin and Marshall, E. BLUME. The Demand for Risky Assets. The American Economic Review. Dec., 1975, Vol. 65, No. 5, p. 900-922.

[24] FERNANDEZ, J., Pablo, AUGURREMALLOA and H. LIECHTENSTEIN. The Equity Premium Puzzle: High Required Premium, Undervaluation and Self Fulfilling Prophecy. *IESE Business School WP,* 2009.

[25] GUESMI, Khaled and Frederic, TEULO. Regional Equity Risk Premium Convergence: The case of Japan. *IPAG working papers series*, 2013.

[26] HASSAN, Shakill and Andrew, V. BILJON. The Equity Premium and Risk-Free Rate Puzzles in a Turbulent Economy: Evidence from 105 Years of Data from South Africa, *South African Journal of Economics*, 2010.

[27] HANSEN, L. Peter and Ravi, JAGANNATHAN. Implications of Security Market Data for Models of Dynamic Economy. *Journal of Political Economy*, April 1991.

[28] HAN, Yuzhe. An Empirical Study of Consumer Asset Pricing Model on China's Stock Market Equity Premium. Financial Economy, April 2013.

[29] LINTNER, John. The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets. *The Review of Economics and Statistics*, February, 1965, Vol. 47, No. 1, p. 13-17.

[30] LUCAS, E. Robert. Asset Prices in an Exchange Economy. *Econometrics*. November 1978, Vol.46, No.6.

[31] LIN, Ludong. Equity Premium Puzzle in China: An Empirical Study Based on the H-Ĵ Variance Bound. *Southern Economy*. Dec. 2007, No. 12,.

[32] LI, Xiang. Empirical Research on Stock Premium Measurement in China's Securities Market. *Nanjing University of Aeronautics and Astronautics*, 2008.

[33] LIAO, Li and Yihui, WANG. Research on Risk Premium in China's Stock Market. *Financial Research*, Apr. 2003.

[34] MARKOWITZ, Harry. Portfolio Selection. *The Journal of Finance*, March 1952.

[35] MEHRA, Rajnish. and E.C PRESCOTT. The Equity Premium A Puzzle. *Journal of Monetary Economics*, 1985.

[36] MEHRA, Rajnish. The Equity Premium: Why Is It A Puzzle. *Financial Analysts Journal*, 2003.

[37] MERHA, Rajnish. The Equity Premium in India. *Working paper* 1234*,* August 2006.

MERTON, Robert. An Intertemporal Capital Asset Pricing Model. *Econometrica*, 1973, Vol. 41, Issue 5, p. 867-87.

[38] MCGRATTAN, R. Ellen and Edward, C. PRESCOTT. Average Debt and Equity Returns: Puzzling? *American Economic Review*. May 2003, Vol. 93, No. 2.

[39] MOSSIN, Jan. Equilibrium in a Capital Asset Market. *Econometrica,* October 1966, Vol. 34, No. 4, p. 768-783.

[40] PASTOR, Lubos and Robert, F. STAMBAUGH. The Equity Premium and Structural Breaks. *Journal of Finance,* 2001.

[41] RUBINSTEIN, Mark. The Valuation of Uncertain Income Streams and the Pricing of Options. *Bell Journal of Economics*. 1976, Vol. 7, Issue 2.

[42] SHARP, F. William. A Simplified Model for Portfolio Analysis. *Management Science,* 1963, p. 277-293.

[43] SUNDARESAN, M. Suresh. Intertemporally Dependent Preferences and the Volatility of Consumption and Wealth. *The Review of Financial Studies*, Vol 2, Issue 1, January 1989.

[44] SHAO, Xijuan, Yaxin, LI and Yanna, LUO. Research on Estimating the Risk Premium of China's Stock Market by Using Horizontal Adjustment Method. *Journal of Finance and Accounting,* December 2013.

[45] TAMURA, Hideaki and Yoichi, MATSUBAYASHI. Solution to the Equity Premium Puzzle and the Risk-free Rate Puzzle: Theory and Evidence. *Discussion paper*, 2014.

[46] TVERSKY, Amos and Daniel, KAHNEMAN. Advances in Prospect Theory: Cumulative Representation of Uncertainty. *Journal of Risk and Uncertainty*. 1992, Vol 5.

[47] TAO, Qingmei. Solution of Stock Premium. *Economic Theory Research*, July 2007.

[48] WEIL, Philippe. The Equity Premium Puzzle and the Risk-Free Rate Puzzle. *J. Monetary Econ.* 24, November 1989.

[49] WANG, Jinbing. Equity Premium: China's Stock Market from 1994 to 2004. *Financial Research*, Mar. 2004.

[50] WANG, Yintian and Yingzi, ZHU. Research on Risk Premium in China's Stock Market. *Financial Research*, 2011.

[51] WANG, Liping. Consumption, Income Constraints and Equity Premium. *Economic Research Guide,* May 2007.

[52] WANG, Hui and Lihong, MA. The Puzzle Equity Premium under the Framework of Complete Market. *Journal of Hebei University of Science and Technology*, Feb. 2010.

[53] ZHANG, Shude. Research on Behavioral Asset Pricing Model: An Analysis between Investment and Consumption. *Financial Research*. Nov. 2005, Vol. 31, No. 11,.

[54] ZHU, Shiwu and Chun, ZHENG. Equity Premium Research in China's Stock Market. *World Economy*, Nov. 2003.

[55] ZHU, Bo, Fengjun, XIE and Chengzhen, RONG. Research on the Time Variability of Equity Premium in China's Stock Market. *Statistics and Decision,* Apr. 2009.

[56] ZHU, Kefu and Shiyun, ZHENG. Prospect Theory and Its Interpretation of Stock Premium: Based on Empirical Analysis of China's Securities Market. *Journal of Southwest Agricultural University (Social Science Edition),* November 2013.

[57] ZHANG, Qian. Analysis of the Impact of the Equity Premium on the Securities Market. *Business Economics,* 2015.

c)Electronic documents and others

[1] China's stock market information. China Security Regulatory Commission. [online]. [3.31.2019]. Available on: http://www.csrc.gov.cn/pub/newsite/sjtj

[2] China's stock market information. Eastmoney. [online]. [3.31.2019]. Available on: http://data.eastmoney.com/cjsj/gpjytj.html

[3] Prospect theory. Investopedia. [online]. [3.31.2019]. Available on: https://www.investopedia.com/university/behavioral_finance/behavioral11.asp

[4] CPI. National Bureau of Statistics. [online]. [3.31.2019]. Available on: http://data.stats.gov.cn/english/easyquery.htm?cn=C01

[5] Stock index price. [online]. [3.31.2019]. Available on: http://www.sse.com.cn/market/overview/; http://www.szse.cn/English/siteMarketData/indices/performance/index.html

[6] Population. [online]. [3.31.2019].http://data.stats.gov.cn/english/easyquery.htm?cn=C01

[7] Total retail sales of consumer goods. [online]. [3.31.2019]. Available on: http://data.stats.gov.cn/english/tablequery.htm?code=AA1510

[8] One-year deposit rate. People's Bank of China. [online]. [3.31.2019]. Available on: http://www.pbc.gov.cn/zhengcehuobisi/125207/125213/125440/125838/125888/2968982/index.html

List of Abbreviations

AR	Auto-regression
ADF	Augmented Dickey-Fuller
CPI	Consumer Price Index
CRRA	Coefficient of Relative Risk Aversion
CAPM	Capital Asset Pricing Model
CCAPM	Consumption Capital Asset Pricing Model
DF	Dickey-Fuller
EIS	Elasticity of Intertemporal Substitution
EP	Equity Premium
EPP	Equity Premium Puzzle
EGARCH	Exponential Generalized Autoregressive Conditional Heteroskedasticity
GEU	Generalized Expected Utility
GMM	Generalized Moment Model
GARCH	Generalized Autoregressive Conditional Heteroskedasticity
H-J Bound	Hansen-Jagannathan Bound
ICAPM	Intertemporal Capital Asset Pricing Model
I.I.D	Individually Identically Distributed
MRP	Market Risk Premium
OLG	Overlapping Generation
P/E	Price/ Earning
REITS	Real Estate Investment Trusts
SDF	Stochastic Discount Factor
SHSE	Shanghai Stock Exchange
SZSE	Shenzhen Stock Exchange
SH	Shanghai
SZ	Shenzhen

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Ostrava dated 23. 4. 2019

Xingyu Chen

Student's name and surname

List of Annexes

Annex I

Annual inflation rate

Time	Inflation rate
1991	3.56%
1992	6.34%
1993	14.56%
1994	24.18%
1995	17.07%
1996	8.33%
1997	2.81%
1998	-0.78%
1999	-1.40%
2000	0.35%
2001	0.73%
2002	-0.77%
2003	1.17%
2004	3.91%
2005	1.83%
2006	1.47%
2007	4.77%
2008	5.90%
2009	-0.68%
2010	3.33%
2011	5.41%
2012	2.65%
2013	2.63%
2014	1.99%
2015	1.44%
2016	2.01%
2017	1.55%
2018	2.01%

Source: China's National Bureau of Statistics

Annex II

Annual yield of risky assets

Time	SH Composite Index		SZ Component Index		Shanghai Shenzhen 300 Index	
	Price	Real yield	Price	Real yield	Price	Real yield
1991	127.61	131.05%	963.57			
1992	292.75	159.60%	2309.77	133.4%		
1993	780.39	-0.82%	2225.38	-10.6%		
1994	833.8	-28.32%	1271.05	-47.3%		
1995	647.87	-9.08%	987.75	-17.6%		
1996	555.29	78.46%	3215.82	251.8%		
1997	917.01	37.21%	4184.84	37.1%		
1998	1194.1	-0.49%	2949.31	-27.0%		
1999	1146.7	19.92%	3369.61	15.0%		
2000	1366.58	49.08%	4752.75	38.6%		
2001	2073.47	-20.92%	3325.66	-30.3%		
2002	1645.97	-16.27%	2759.3	-15.8%		
2003	1357.65	8.15%	3479.8	23.7%		
2004	1497.04	-2.64%	3067.57	-14.2%		
2005	1266.49	-20.86%	2863.61	-4.7%	923.45	
2006	1161.05	131.25%	6647.14	132.9%	2041.04	121.81%
2007	2675.47	90.46%	17700.62	157.9%	5338.27	153.31%
2008	5261.56	-65.76%	6485.51	-63.8%	1817.72	-66.31%
2009	1820.81	91.91%	13699.98	125.2%	3575.68	109.74%
2010	3277.13	-17.64%	12458.55	-12.6%	3128.26	-15.91%
2011	2808.07	-23.22%	8918.82	-29.8%	2345.74	-26.49%
2012	2199.417	5.94%	9116.5	5.0%	2522.95	10.45%
2013	2269.128	-6.73%	8121.79	-10.9%	2330.03	-7.63%
2014	2115.978	53.83%	11014.63	36.5%	3533.71	52.61%
2015	3234.677	10.01%	12495.25	14.1%	3772.617	7.34%
2016	3539.182	-12.80%	11037.12	-12.2%	3310.08	-12.75%
2017	3103.637	7.04%	10941.87	-0.4%	4030.85	22.33%
2018	3307.172	-24.93%	7901.83	-28.1%	3010.65	-25.65%

Source: SHSE, SZSE, author

Annex III

One-year deposit rate announced by People's Bank of China

15/4/1990	10.08%	29/10/2004	2.25%	26/12/2010	2.75%
21/8/1990	8.64%	19/8/2006	2.52%	9/2/2011	3.00%
21/4/1991	7.56%	18/3/2007	2.79%	6/4/2011	3.25%
5/15/1993	9.18%	19/5/2007	3.06%	7/7/2011	3.50%
11/7/1993	10.98%	21/7/2007	3.33%	8/6/2012	3.25%
1/5/1996	9.18%	22/8/2007	3.60%	6/7/2012	3.00%
23/8/1996	7.47%	15/9/2007	3.87%	22/11/2014	2.75%
23/10/1997	5.67%	21/12/2007	4.14%	1/3/2015	2.50%
25/3/1998	5.22%	9/10/2008	3.87%	11/5/2015	2.25%
1/7/1998	4.77%	30/10/2008	3.60%	28/6/2015	2.00%
7/12/1998	3.78%	27/11/2008	2.52%	26/8/2015	1.75%
10/6/1990	2.25%	23/12/2008	2.25%	24/10/2015	1.50%
21/2/2002	1.98%	20/10/2010	2.50%		

Source: People's Bank of China

Annual weighted average deposit rate and real riskless rate of return

Time	Deposit rate	Real riskless rate
1990	8.66%	13.56%
1991	8.69%	9.46%
1992	9.18%	6.33%
1993	9.46%	1.61%
1994	9.18%	0.72%
1995	9.18%	15.81%
1996	9.15%	17.96%
1997	7.12%	12.88%
1998	5.02%	8.82%
1999	2.92%	3.57%
2000	2.25%	0.47%
2001	2.25%	1.86%
2002	2.02%	3.56%
2003	1.98%	0.02%
2004	2.03%	-0.66%
2005	2.25%	4.34%
2006	2.35%	2.71%
2007	3.20%	-0.05%
2008	3.93%	2.82%
2009	2.25%	9.02%
2010	2.38%	-1.60%
2011	3.28%	1.24%
2012	3.24%	6.01%
2013	3.00%	3.02%
2014	2.97%	3.62%
2015	2.12%	2.67%
2016	1.50%	0.93%
2017	1.50%	1.96%
2018	1.50%	1.04%

Source: author

Annex IV

Total retail sales of consumer goods

Time	Total retail sales of consumer goods (billion)	Real growth rate
1990	83	2.50%
1991	94.15	12.02%
1992	109.937	11.70%
1993	142.704	17.50%
1994	186.229	17.44%
1995	236.138	28.59%
1996	283.602	25.03%
1997	312.529	13.94%
1998	333.781	9.22%
1999	356.479	6.39%
2000	391.057	6.74%
2001	430.554	8.55%
2002	481.359	12.01%
2003	525.163	6.17%
2004	595.01	9.23%
2005	683.526	15.30%
2006	791.452	14.49%
2007	935.716	13.03%
2008	1148.301	18.89%
2009	1330.482	20.65%
2010	1580.08	12.76%
2011	1872.058	14.48%
2012	2144.327	15.74%
2013	2428.428	11.97%
2014	2718.961	11.41%
2015	3009.308	10.19%
2016	3323.163	8.77%
2017	3662.616	9.65%
2018	3809.87	3.11%

Source: China’s National Bureau of Statistics, author

Annex V

Total population and growth rate

Time	Population (million)	Simple growth rate	Exponential growth rate
1991	1158.23	1.3032%	1.2948%
1992	1171.71	1.1638%	1.1571%
1993	1185.17	1.1487%	1.1422%
1994	1198.50	1.1247%	1.1185%
1995	1211.21	1.0605%	1.0549%
1996	1223.89	1.0469%	1.0414%
1997	1236.26	1.0107%	1.0056%
1998	1247.61	0.9181%	0.9139%
1999	1257.86	0.8216%	0.8182%
2000	1267.43	0.7608%	0.7579%
2001	1276.27	0.6975%	0.6951%
2002	1284.53	0.6472%	0.6451%
2003	1292.27	0.6026%	0.6007%
2004	1299.88	0.5889%	0.5872%
2005	1307.56	0.5908%	0.5891%
2006	1314.48	0.5289%	0.5275%
2007	1321.29	0.5184%	0.5170%
2008	1328.02	0.5094%	0.5081%
2009	1334.50	0.4879%	0.4868%
2010	1340.91	0.4803%	0.4792%
2011	1347.35	0.4803%	0.4791%
2012	1354.04	0.4965%	0.4953%
2013	1360.72	0.4933%	0.4921%
2014	1367.82	0.5218%	0.5204%
2015	1374.62	0.4971%	0.4959%
2016	1382.71	0.5885%	0.5868%
2017	1390.08	0.5330%	0.5316%
2018	1395.38	0.3813%	0.3805%

Source: China’s National Bureau of Statistics, author